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Publié par le Secrétaire général

FRANCESCO SIGNORE

Série II — Tome XIV

B. V.

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(Voir la suite à p. 3 de la couverture)

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SIGURDUR THORARINSSON

The Crater Groups in Iceland

(With 14 text-figures and 17 plates)

Introductory.

The river Laxá in Sudur -Thingeyjarsysla, N. Iceland, is more closely connected with recent lava flows than any other river in Iceland. Its source, Lake Myvatn (38 km^2) is wholly surrounded by postglacial lava flows, which also constitute its bottom. From the point where it leaves this lake, Laxá runs wholly or partly on postglacial lava until it plunges over a low lava cliff 1 km before reaching the Skjálfandi Bay.

As a geological and geotechnical consultant in the building of a power station in the river Laxá at Laxárgljúfur (the Laxá Canyon) and for the regulation of Lake Myvatn my task was mainly to study the lava flows constituting the banks and bottom of the river and lake. These studies, which started in 1946, soon led to a study of the numerous crater groups in the Myvatn-Laxá area. Before dealing with these crater groups a short description of the Laxá lava flows is necessary (1).

The Laxá lava flows.

In leaving the Laxárdalur valley which is hanging in relation to the broader and more deeply glacially eroded Adaldalur the river Laxá has eroded the rock barrier at the mouth of the valley, forming a canyon called Laxárgljúfur (Pl. II). This canyon is 1,7 km long, 70-140 m wide and 15-20 m deep. The present bottom of Laxárgljúfur consists of lava, which has flown down the canyon from Laxárdalur and spread over the Adaldalur plain.

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(1) The present paper is mainly an abstract of a paper: *Laxárgljúfur and Laxárhraun,* published in Geografiska Annaler. H. 1-2. Stockholm 1951. For a more detailed description of the Laxá lava flows I refer to that paper.

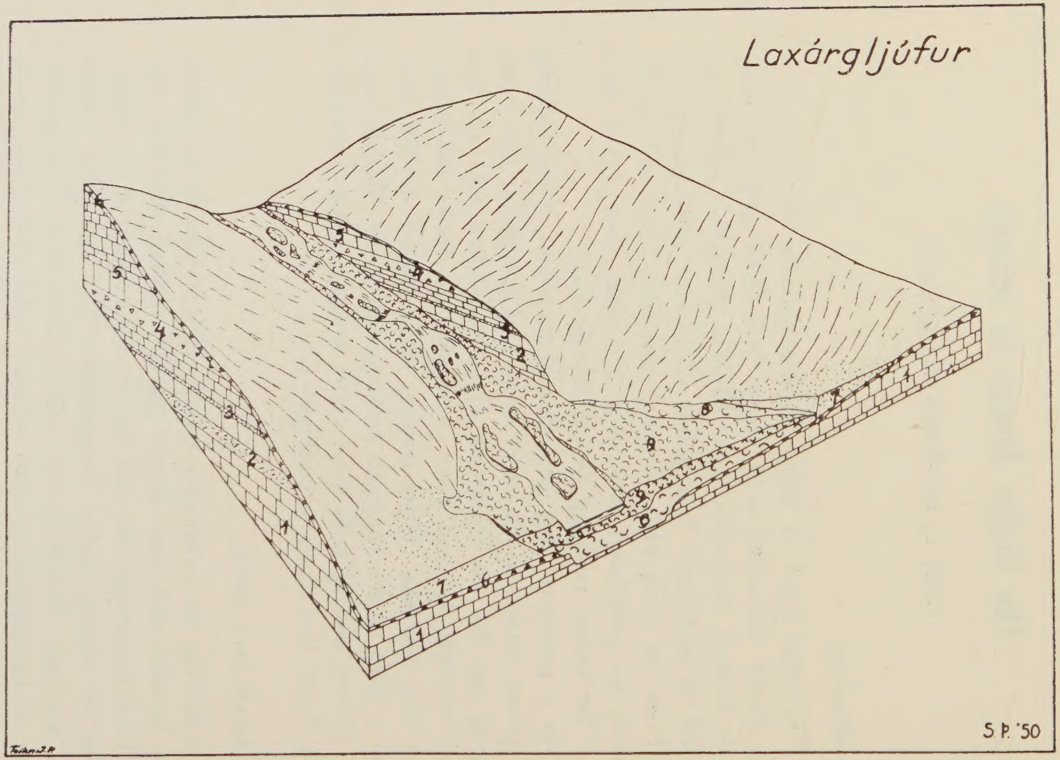

Fig. 1. - Schematic block diagram of Laxárgljúfur. 1 and 5: Basalt sheets. 2 and 3: Tuff layers. 4: Tillite. 6: Ground moraine. 7: Gravel terraces. 8: Older Laxárhraun. 9: Younger Laxárhraun.

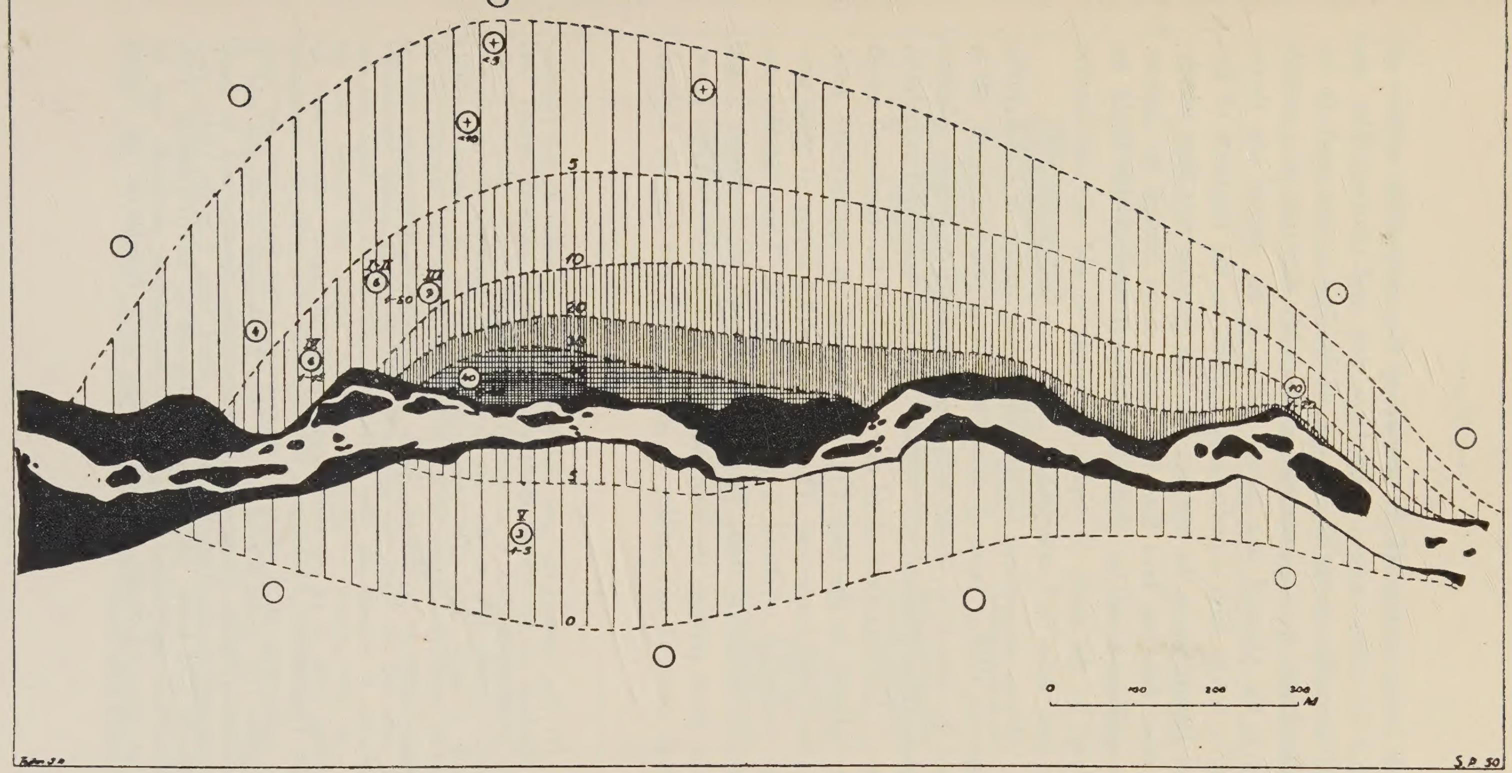

Fig. 2. - The extent and thickness (in cm) of the scoria-lapilli layer at Laxárgljúfur. The dashed lines are isopachytes. Roman numerals indicate soil profiles measured in detail. Numerals in circles give the thickness of the tephra layer, numerals below the diameters of the ejecta (in cm.). Circles with cross inside indicate that tephra was found, empty circles that no tephra was found. Black: Younger Laxárhraun.

This is an aa-lava (Icel. *apalhraun*) the scoriaceous surface of which is rather uneven, with large pits and cavities. This aa-lava naturally, owing to the risk of leakage, is not well fit for a foundation for a power station dam. My first task as a consultant to the planned new power station in the canyon was therefore to try to form a preliminary opinion on the thickness of this lava foundation in the canyon. The first question was then whether more than one lava flow had come down through the canyon. By application of the tephrochronological method this could be solved by the study of tephra (1) layers in soil sections outside the lava flow in Laxárgljúfur.

When excavations for the first power station in Laxárgljúfur began in 1938 a layer of scoria was, in a soil section ab. 60 m from the lava flow, found to be superimposed on a light coloured tephra layer (SNORRASON, 1940). My first task at Laxárgljúfur was a close examination of this scoria layer, the results of which are collated in the map Fig. 2, showing its approximate area, thickness and coarseness. The position of the layers in some profiles examined in detail is shown in Fig. 3. These profiles are situated in loessial soil. The layers H_3 and H_4 (=layers 5 and 7) in these profiles are both light-coloured rhyolitic tephra layers which occur in soil profiles in whole North and Central Iceland.

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(1) The nomenclature and classification used in volcanological literature in speaking of the clastic ejectamenta are rather confused, which inter alia is due to the lack of a collective term for all clastic volcanic ejectamenta, corresponding to the term lava for all materials flowing from a crater in liquid form. The term (volcanic) ash is for instance generally used to represent fractions of a certain grain size (« Das Material bis zu Hirsekorngrösse », v. WOLFF, 1940, p. 191), but in combinations such as ash cone and ash layer, ash is actually used to signify clastic ejectamenta generally. A volcanic ash cone consists of course not of ash alone, but also — and often mainly — of lapilli, pumice, scoria, and blocks, and the proximal parts of an ash layer consist mainly of coarser material than ash (cfr. THORARINSSON, 1944, pp. 112-117, 210). To avoid this inconsistent use of the term ash, I am in this paper using a term that I have previously suggested, viz. *tephra* (Greek = ash, used by Aristotle of volcanic ash), as a collective term for all pyroclasts, corresponding to the term lava, to signify the material flowing from the crater in liquid form. I prefer tephra as a collective term before ash, which was proposed by BLYTH (1940, p. 150), as the first named term is linguistically more closely associated with the terms lava and magma, without leading one's thoughts to any definite fractional grain sizes.

The extent of H_3 is shown on Fig. 4. H_4 has approximately the same extent.

My tephrochronological investigations (THORARINSSON, 1944, 1951) have proved that both these layers come from Mt. Hekla and so do also the layers designated H_1 and H_5 in the soil profiles. The position of these layers in peat soils in relation to layers of birch trunks and « recurrence levels » offers possibility of an approximate dating. From this it may be concluded that the age of H_3 is probably 2500-3000 years, the age of H_4 ab. 4500 years. A more exact dating will probably be possible by

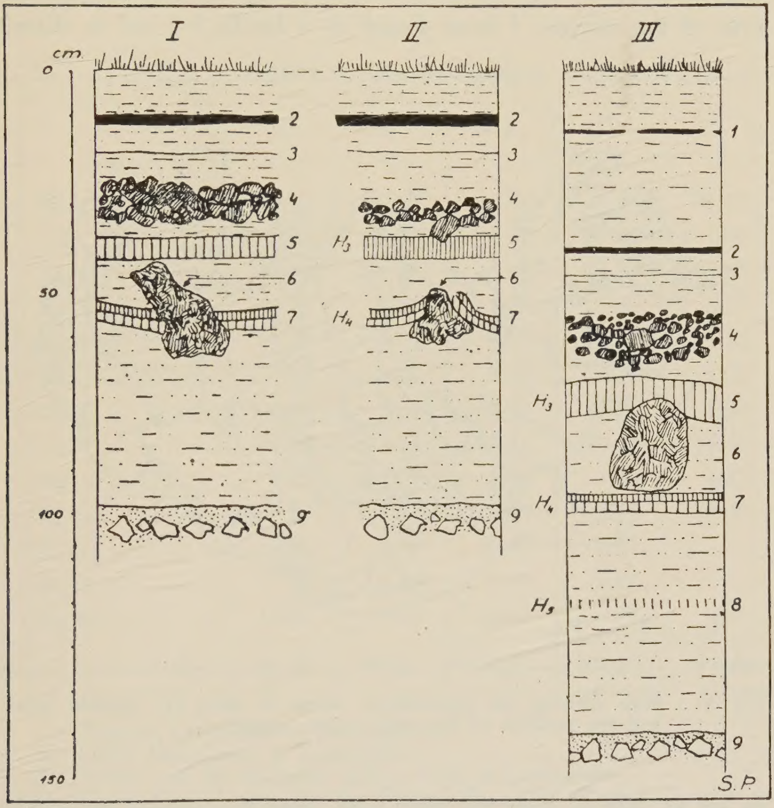

Fig. 3. - Soil profiles at Laxárgljúfur. Legend see Fig. 14. The position of the profiles is shown in Fig. 2.

means of the carbon^{14} method. The layer H_1 is probably formed by Heklas first eruption in historical time, 1104 A. D.

The profiles in Laxárgljúfur prove that the scoria layer is at least some centuries younger than H_3. The scoria layer is, as will be seen in the map, most extensive and thickest on the NE side of the canyon. I have found in it lapilli 1-2 cm in diam. as far as 500 m from the lava flow, from the surface of which it is, however, absent. The particle diam. of the material diminishes fairly regularly with increasing distance from the lava flow. Scoria up to 40 cm in diam. may be found nearest to the flow, but in the most distal parts only small lapilli. Besides scoria there are also globular bombs (Pl. IV) with a dense outer shell and a somewhat more porous core.

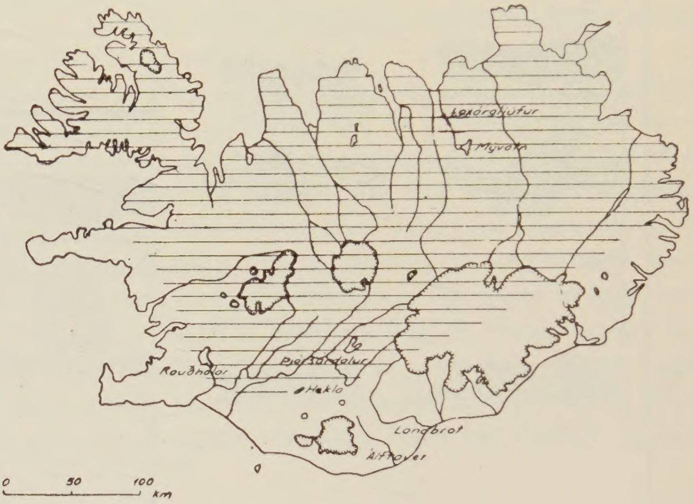

Fig. 4. - Map showing the approximate extent of layer H_3 (shaded area) and the position of the main crater groups.

The lava forming the present bottom of Laxárgljúfur is, as shown by analysis I, Table I, a fairly typical basalt lava. It is of pronouncedly porphyritic texture and dark greyish ground mass. All the large phenocrysts consist of light greyish plagioclas (An 85-90). Small pyroxene and olivine granules also occur. The scoria in the above mentioned layer are of exactly the same felspar-porphyritic texture as the lava flow and agree well with it in chemical composition. This and its distribution in respect of thickness and particle diam. exclude any doubt of its derivation from the lava flow that has come down the canyon. Had another lava flow come down the canyon previously, one would accordingly expect also scoria from this in the soil profiles and actually I did so on closer examination. In the profiles I-III some scoria were found below H_3 and these could accordingly not be

TABLE I. *Chemical analyses.*

	I	II	III	IV	V
SiO_2	49.30	48.80	48.06	48.10	46.97
TiO_2	1.10	0.97	1.54	1.60	1.99
Al_2O_3	14.98	16.79	16.32	15.30	13.87
Fe_2O_3	0.90	0.40	1.87	1.25	8.27
FeO	9.27	8.83	9.77	10.05	5.76
MnO	0.19	0.17	0.20	0.20	1.20
MgO	6.96	6.83	7.44	8.08	4.76
CaO	12.63	12.54	12.52	13.12	14.46
Na_2O	2.15	2.09	2.04	1.85	1.75
K_2O	0.91	1.01	0.54	0.67	0.45
P_2O_5	0.28	0.32	0.00	0.00	—
H_2O+	0.79	0.86	0.00	0.00	—
H_2O-	0.00	0.00	0.12	0.18	—
S:a	99.46	99.61	100.42	100.40	99.48

I: Younger Laxárhraun at Laxárgljúfur.
II: Older Laxárhraun at Laxárgljúfur.
III: Scoria from the secondary tephra layer at Laxárgljúfur.
IV: Scoria from a crater in the Skútustadir crater group.
V: Scoria from Raudhólar at Ellidavatn.
I-II: Analyst, Svavar HERMANNSSON; III-IV: Analyst, Naima SAHLBOM;
V: Analyst, HAUSER (from KOMOROWICZ, 1912, p. 25).

connected with the scoria of the upper layer. Profile III shows that these scoria are somewhat younger than H_4.

Thus it was proved by study of soil sections that two lava flows had come down through Laxárgljúfur, one after the deposit of layer H_4 but before that of H_3, the other after the deposit of H_3. Later drillings in the canyon itself fully confirmed this. The underlying lava flow proved to be of almost exactly the same chemical composition (Table I, no. II) and to contain the same felspar phenocrysts (An 85-90) as the upper layer and this also applies to the scoria found underneath the layer H_4.

The two lava flow are henceforth in this paper designated *the younger Laxárhraun* or *the younger Laxá lava flow*, and *the older Laxárhraun* or *the older Laxá lava flow*.

The extension, sources and ages of the Laxá lava flows.

Having succeeded in determining the position of the two Laxá lava flows in relation to the tephra layers H_3 and H_4 it was with their aid possible to determine rather accurately the boundaries and extension of these lava flows and follow them to their respective sources. Their extension is shown on the map Pl. I.

The source of *the younger Laxárhraun* is the Threngslaborgir and its continuation northwards, Lúdentsborgir (cf. the map Fig. 5). Between them these craterrows are 8,5 km long. A single crater in the canyon Seljahjallagil on the same N-S line as Threngslaborgir has also erupted at the same time. Threngslaborgir (Pl. V) has been thoroughly described by RITTMANN (1938, 1939). He has also attempted a reconstruction of the eruptions in Threngslaborgir-Lúdentsborgir and in his excellent textbook on volcanology (1944) he gives this as a typical example of a fissure eruption. As far as I can see his reconstruction is fundamentally correct (1) but far more lava was

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(1) In my previous paper (THORARINSSON, 1951) I have maintained that a black, coarse-grained tephra layer which is found everywhere in the Myvatn area (layer h in the profiles Fig. 14) was produced in the first phase of the Threngslaborgir eruption. Further investigations (THORARINSSON, 1952) have shown that this layer was not at all produced by the Threngslaborgir eruption, but by the eruption which has built up the famous tephra ring Hverfjall.

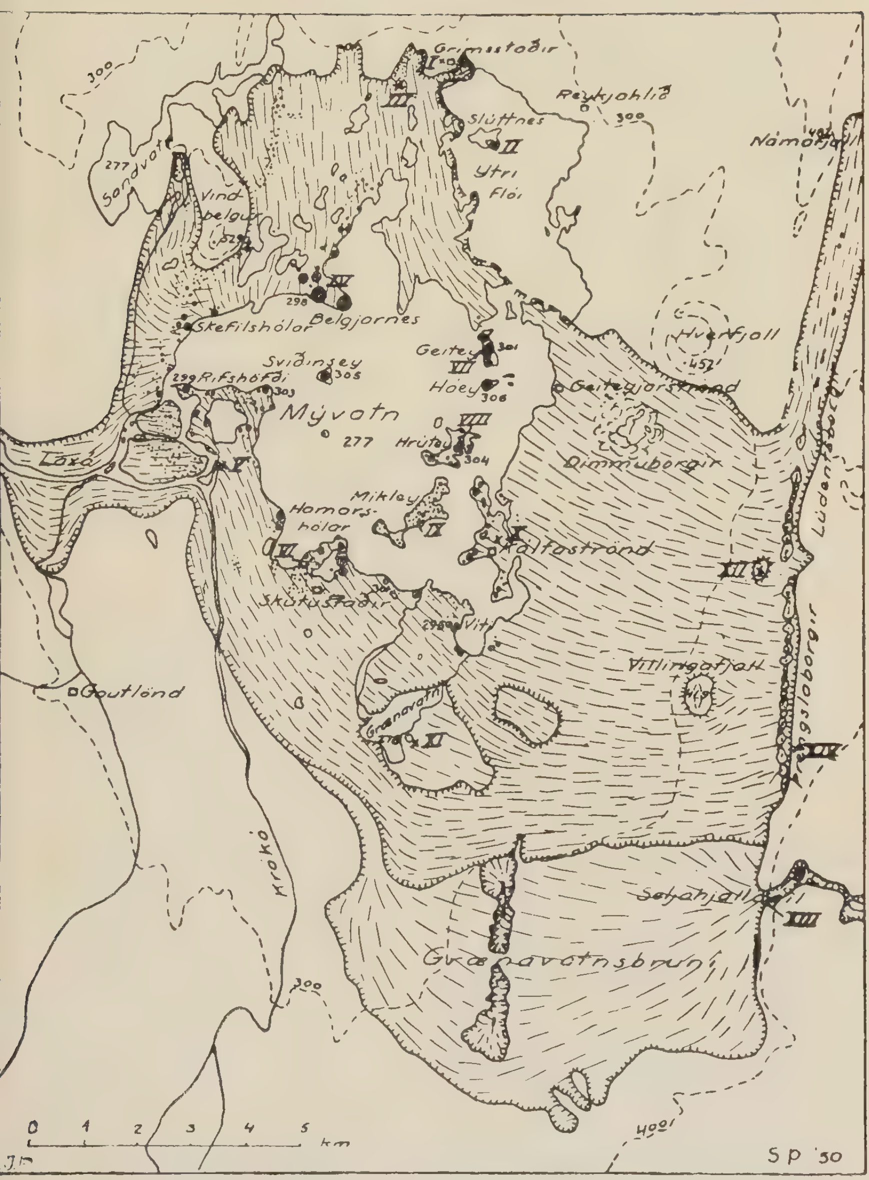

Fig. 5. - Map showing the extension of the two Laxá lava flows and the position of the crater groups in the Myvatn area (dots and filled circles). The soil profiles in Fig. 14 are marked with an x and Roman numerals.

produced during the main phase of the eruption than indicated in RITTMANN's geological map of the Myvatn area. The longest lava flow from Threngslaborgir-Lúdentsborgir marked in this map is ab. 6 km long and the total area of the lava ab. 25 km^2. Actually the total length of the younger Laxárhraun is 52 km and its total area ab. 170 km^2. Assuming an average thickness of 15 m this would make the total volume of the lava 2.5 km^3.

With the exception of some small streams of a ropy *helluhraun* (pahoe-hoe) character that flowed from the crater rows in the final phase of the eruption, the younger Laxá flow is preponderantly *apalhraun* (aa) with a rough and jagged surface.

The position of the upper scoria layer in relation to H_3 in the Laxárgljúfur soil profiles enables us to say with certainty that the younger Laxá lava is considerably younger than the layer H_3. It is on the other hand certain that it was erupted many centuries before Iceland was colonized in ca. 900 A. D. Its probable age is from 1800-2300 years.

The older Laxárhraun is, as beforesaid, of almost exactly the same chemical composition and texture as the younger one, but it is preponderantly of *helluhraun* type. The source of this lava is the summit crater of Ketildyngja, a shield-volcano of a type frequent in the Ódádahraun region, and it was produced by the last eruption of this shield-volcano and possibly the last shield-volcano eruption in the Ódádahraun area upon the whole. From Ketildyngja the lava has flowed down the canyon Seljahjallagil and spread over the Myvatn area where it probably underlies the most part of the younger Laxárhraun. The length of the lava flow from the summit crater of Ketildyngja to Skjálfandi is 82 km. It is the longest but one of the postglacial shield-volcano lava flows in Iceland, and consequently also in the whole world. The area of the lava flow can only be roughly estimated, as it is somewhat doubtful how far it extends beneath younger lava flows. An approximate minimum value of the area of older Laxárhraun is 330 km^2. Assuming an average thickness of 12 m, its volume will be about 4 km^3.

The soil profiles prove the older Laxárhraun to be younger than the layer H_4, but many hundred years older than the layer

H_3. Its age is most likely between 3500 and 4500 years. It is of special interest to note that the discovery that Ketildyngja is the source of the older Laxárhaun has for the first time made an approximate dating of an eruption of a shield-volcano in Iceland possible. As the older Laxárhraun derives from one of the last — or even the very last — shield-volcano eruption in the Ódádahraun region, the tephrochronological dating of this lava flow is accordingly giving us an approximate time limit for the cessation of shield-volcano activities in Iceland. The shield-volcanoes, though still active in Iceland ab. 4500 years ago, have probably all been extinct, at any rate in northern Iceland, for more than 3500 years. A more exact dating might well be possible with the aid of pollen analysis and the radiocarbon method.

The Crater Groups in the Myvatn - Laxá areas.

One of the characteristics of the younger Laxá lava flow is the great number of craters on this flow. Their exact number must run well into four figures. On one small island in Myvatn, Mikley, v. KNEBEL counted 107 craters, and 22 on the adjacent Hrútey (1905). The Grímsstadaborgir crater group SW of Grímsstadir contains much more than 100 craters.

I have tried to plot craters and crater groups on the map Pl. I and Fig. 5. In the Myvatn area, where I have visited all the crater groups, and have had access to good aerial photos, this is done more exactly (although only approximately) than in the Adaldalur area, where they are put in very schematically.

The northernmost craters in the Adaldalur area are situated on the older lava. They are few, all of small sizes. They include Goshólar on the Sílalækur farm and a group of small craters and « Schweiss-Schlacken » cones SW of the Knútsstadir farm. All other craters and crater groups in Adaldalur, Laxárdalur and the Myvatn area are situated on the younger Laxá lava. The whole lava plain from the neighbourhood of the Tjörn farm in the N to the crater group in Gálgahraun in the S, an area of ab. 28 km^2, is more or less densely pitted with several hundred craters, varying from a few metres in diameter to twenty or thirty, and from 1 to 15 m in height.

East of Laxá in the northern part of Laxárdalur there is a group of about 25 or 30 craters, Raudhólar (Red Mounds), occupying an area 500 m long and 200-300 m broad (Fig. 6). The highest is 18 m high. There are also a few small craters further south in Laxárdalur.

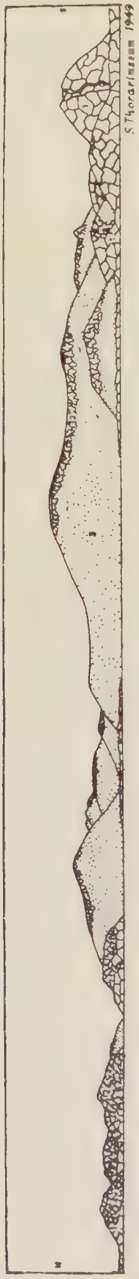

Fig. 6. - The Raudhólar group in Laxárdalur seen from the western bank of the river Laxá. Length of section is 500 m; the relative height of the highest crater 18 m. 1: lava, 2: « Schweiss-Schlacken », 3: Scoria and lapilli. The sketch illustrates a feature typical of many crater groups, viz. that their central craters are mainly built up from lapilli and scoria — though often with an outermost layer of « Schweiss-Schlacken » on the crater rim — while the peripheral parts include all transitional forms to mounds of pure « Schweiss-Schlacken » and cracked lava domes.

The Craters in the Myvatn area.

The largest number of craters are, however, found in the Myvatn area, which is completely crowded with crater groups — veritable lunar landscapes in miniature. The best known of these groups, at Skútustadir (Skútustadagígir, Fig. 7 and Pl. VI), is described and discussed by many volcanologists. Among other crater groups SW of Myvatn may be mentioned Raudhólar and Hamarshólar SW and NW respectively of Álftavogur, and the large groups round lake Blátjörn and the place where Laxá leaves Myvatn. W of Myvatn are Skefilshólar, S of the Vagnbrekka farm, and the large craters on Belgjarnes round the Vindbelgur farm; N of Belgjarnes a row of crater groups and individual craters (Hamar, Raufarhóll, Krosshóll, Botnlausaborg etc.) follow the shore of Myvatn. W of Myvatn there are also the previously mentioned Grímsstadaborgir (1), a group in which all the craters are small, and a little further west the groups Grenisborgir (with Litluborgir), Helguhólsborgir, and Austurklettar, also composed of small craters, and forming a continuous chain from Mt. Vindbelgur to the NE-most part of Lake Sandvatn, and finally Selhöfdi and other craters round the S part of Vindbelgur. Along the S shore of Myvatn we note Fellshóll, the hollow « Schweiss-Schlacken » cone Arnabæli, the Arngardshólar group and Gardshólar. SE and E of the lake are the Sandhólar group E of Gardsflæda, and other crater groups

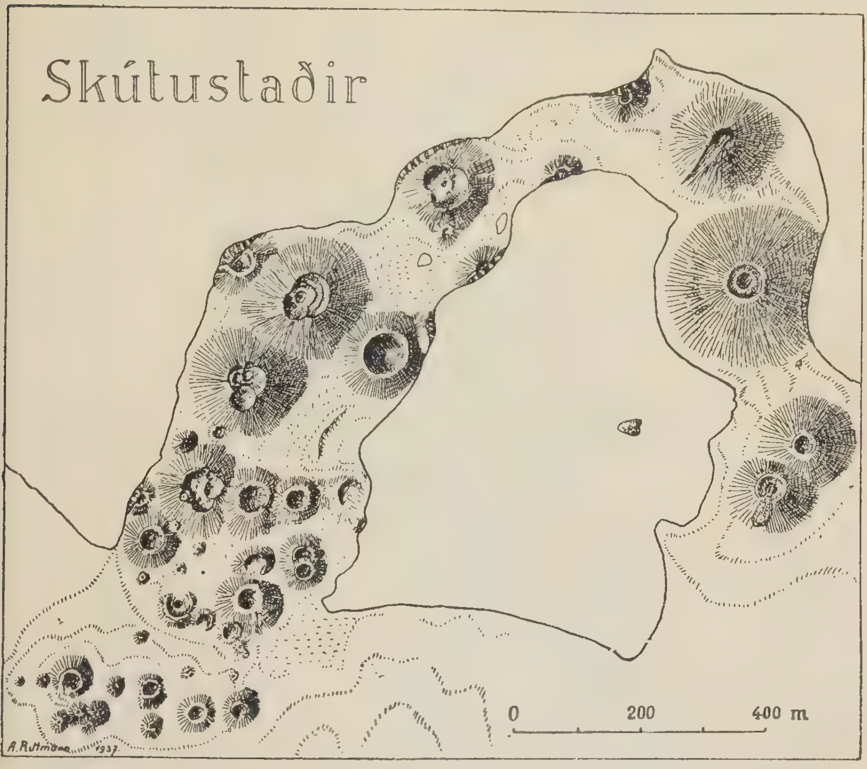

Fig. 7. - The Skútustadir crater group. Sketch map by RITTMANN (1938, Fig. 1). Scale 1:12.000.

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(1) In Thingeyjarsysla many crater groups and crater rows are called *borgir* (= castles). Individual craters are there called *hver*, which term in other parts of the country is generally used to designate hot springs.

N and S of the Kálfaströnd farm. Most of the islands in the south part of Myvatn are also individual craters (Háey, Svidinsey) or crater groups, e. g. the above mentioned Mikley, Hrútey, and Geitey (cf. Figs. 7, 8, 9 and Pl. VI, VII, VIII, IX).

The largest craters as far as volume is concerned — and accordingly the largest of this type in Iceland — are Vesturhöfdi and Austurhöfdi on Belgjarnes situated just W and E respectively of the Vindbelgur farm. The absolute height of Vesturhöfdi is 298 m, i. e. 21 m above the surface of Myvatn, which means that its relative height is about 23 m. The maximum diameter (E-W) of the cone at the summit is 200 m. and its minimum diameter (N-S) 130 m. The depth of the crater is 25 m and the average diameter of the cone at the base about 320 m. The gradient of the crater wall is 25-30° on its inner and 20-25° on its outer side. According to the formula for the volume of a truncated cone, the crater volume may be estimated at about 1 million m^3. Austurhöfdi (Pl. XI), which has not been properly surveyed, is slightly larger. But these craters are not the highest in the area. The highest is the Háey crater (absolute height 306 m, relative height about 32 m). The Svidinsey crater is 305 m, the crater Húshóll on Hrútey 304 m, Ytri Hamar NE of Blátjörn 303 m, Stórihver on Geitey and Fellshóll 301 m. The highest

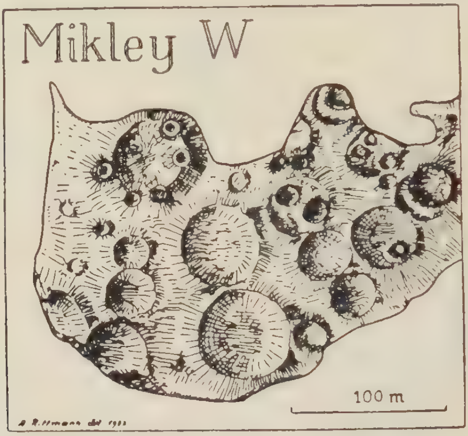

Fig. 8. - The westernmost part of Mikley. Sketch map by RITTMANN (1938, Fig. 2). Scale 1 :5.000.

craters of the Skútustadir group (Kleifarhólar) and the groups along the SW and W shore of the lake are of about the same

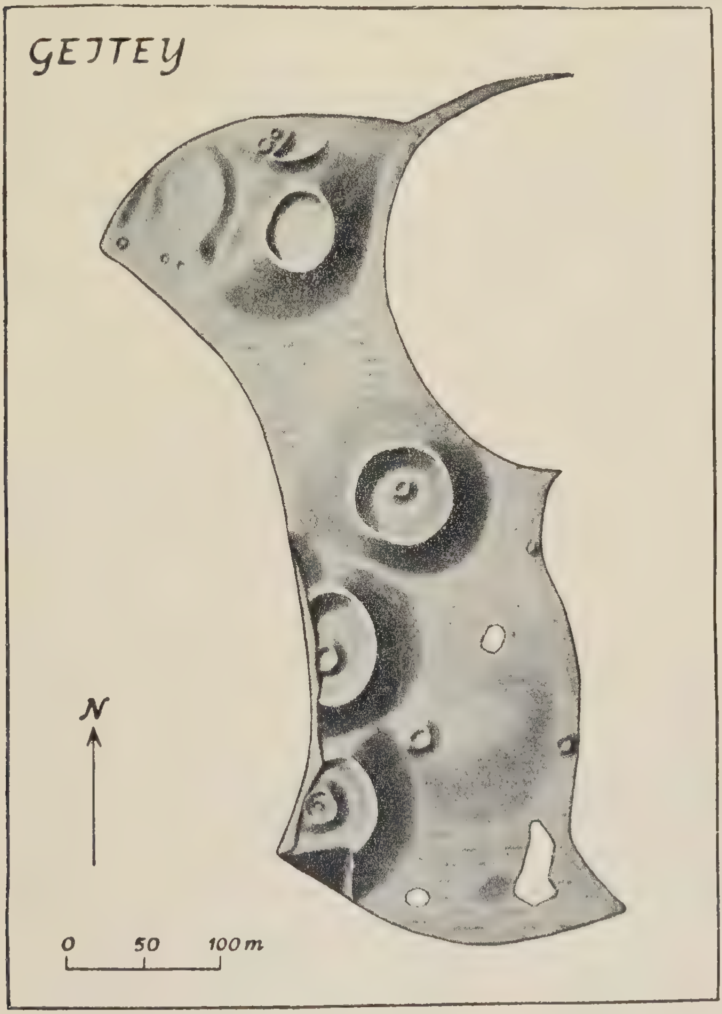

Fig. 9. - Geitey. Sketch map by S. THORARINSSON, 1949. Scale 1:5.000.

height. Generally speaking, however, the Myvatn craters — in each groups as well as in the whole region — vary greatly in size from miniature craters 3 or 5 m in diameter and 1 or 2 m high through all intermediate sizes up to the said large craters. As to the regional dispersion of these sizes, the highest craters occur in the central parts of the area, i. e. in those parts where we have reason to think that the younger Laxárhraun is the thickest.

Thoroddsen states that W and SW of Myvatn the craters are mainly oriented along lines running N-S and NE-SW (1913, I, p. 281), but I have not been able to find any such orientation either of crater groups or individual craters.

In structure and build-up, the craters represent every form from small lava vaults superimposed on scoria (Pl. XII) to regular craters composed entirely of tephra (scoria, lapilli, « Schweiss-Schlacken »). Hornitos, and small explosion funnels without any tephra rings, also occur. The large craters are wholly composed of tephra, and most of them — as pointed out by Rittmann (1938, p. 17) — are of similar structure, in that the sequence of time of the ejecta have been lapilli — scoria — « Schweiss-Schlacken ». The outermost layers of the craters thus generally consist of « Schweiss-Schlacken », the next of scoria, and the bottom layer of lapilli. Some craters, e. g. the well-known Víti in the Arngardshólar group, have central conduits of « Schweiss-Schlacken », open right down to the base of the crater cone (Fig. 10). A few craterless cones, e. g. the previously mentioned 15 m high and wholly hollow Arnarbæli, are built up of « Schweiss-Schlacken » alone (Pl. XIV). Generally, however, « Schweiss-Schlacken » are mostly found in small craters; the largest craters are almost wholly composed of scoria and lapilli. I have found bombs of the type described from Laxárgljúfur in the Skútustadir and other groups. Many craters are double, some

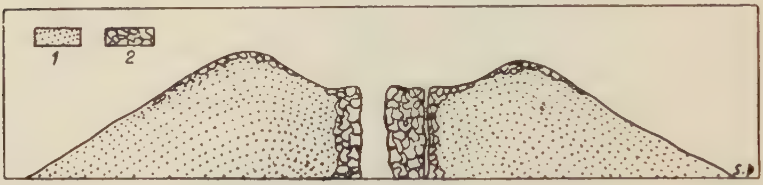

Fig. 10. - Schematic section through the crater V. Víti in the Arngardshólar crater group (cf. Pl. XIII). 1: Scoria and lapilli. 2: « Schweiss-Schlacken ».

of them even triple (cf. the maps), but their inner walls are then always very small in comparison with the outermost wall. Nowhere have I observed any emission of lava. Most craters are low in relation to their basal area. Their wall gradients are usually from 20° to 30° on the outside and from 25° to 30° on the inside. Cones composed of « Schweiss-Schlacken » alone are sligthly steeper (Arnarbæli 35°). Many of the craters, especially on the islets in Myvatn, are of exceedingly beautiful shapes, real miracles of nature in their graceful and yet almost mathematically symmetrical outlines. They consist of very easily eroded materials, which in spite of rather high vol. weight (2.0 - 3.0) are put at the mercy of the waves and currents of the lake. The islets and SW shore of the lake accordingly provide excellent opportunities for the study of shore processes. Different types of spits, bars, forlands and tombolos can be studied there in form approaching the ideal. The larger islands may almost be regarded as complex tombolos. The crater groups at Myvatn are also interesting from the point of view of settlement geography. Nearly all the large craters, consisting of scoria and lapilli, are grass covered both inside and out, and are in fact the principal hay meadows of the adjacent farms. On the insides of the craters, in particular, the grass grows luxuriantly, and no manure except what is provided by nature in the form of midges is required there to provide rich crops of hay. Myvatn is one of the few places in Iceland where there are plenty of midges, and *Simulium vittatum* occurs there in absolutely incredible masses. In the large craters, where there is generally no wind, the sward is in early summer covered by thin layers of dead midges — obviously excellent fertilizers. It would be difficult to find any more peculiar hay meadows that these midge - manured craters. Most farms on the S and W shores of the lake are situated on or close to a crater or group of craters.

Other crater groups in Iceland

Before proceeding to discuss the genesis of the Myvatn-Adaldalur crater groups, I will briefly describe some of the most important crater groups of the same type in other parts of Iceland (cf. the map, Fig. 4).

Raudhólar at Ellidavatn.

The crater group in Iceland, which besides the Myvatn groups, has been most extensively described and discussed is

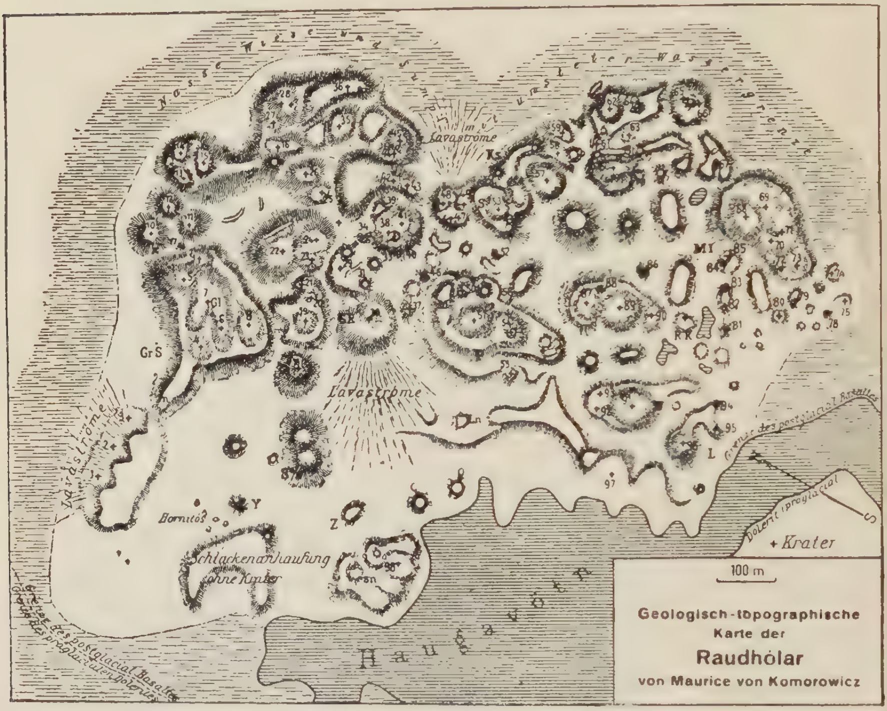
Nordwestliche Wiesen
Lavaströme
Lavaströme
Lavaströme
Gr S
Y
Z
Hornitos
Schlackenanhäufung ohne Krater
Grenze des postglacial Basaltes
Grenze des praglacialen Dolerites
Grenze des postglacial Basaltes
Dolerit (praglacial)
+ Krater
100 m
MI
RR
L
97
Geologisch-topographische
Karte der
Raudhólar
von Maurice von Komorowicz

Fig. 11. - The Raudhólar crater group at Ellidavatn. Mapped by v. KOMOROWICZ, in 1907.

Raudhólar, situated 10 km SE of Reykjavík between the lake Ellidavatn and the great eastern road from Reykjavík. Thanks to its accessibility, this crater group has been visited by numerous volcanologists, and was mapped and thoroughly examined as early as the spring of 1907 by M. v. KOMOROWICZ, whose map is reproduced here on a greatly reduced scale (Fig. 11). Some 90 craters, which — like the craters at Myvatn — are built up of lapilli, scoria, and « Schweiss-Schlacken », and in which — as at Myvatn — the « Schweiss-Schlacken » are less prominent on the larger of the craters, are found there in an area of 1 km^2. Accidental ejecta (« xenoliths ») of doleritic lava, of the type constituting the glacial substratum of this area, are occasionally found among the scoria. Basalt bombs and jagged fragments of basalt lava also occur. According to v. KOMOROWICZ small quantities of lava have been emitted by some craters in the peripheral parts of the group. Small « Schweiss-Schlacken » cones (« hornitos ») also occur, and transitional forms between them and the scoria craters. Most of the craters are of red colour (hence their name « Red Mounds »), but some are brownish black, the two colours occurring irregularly, so that for instance one of a pair of twin craters may be brownish black, the other red. The chemical composition of the scoria is given in Table I. According to v. KOMOROWICZ, the relative height of the highest crater is 40 m, but engineer S. ÓLAFSSON, Reykjavík, has kindly put at my disposal more exact tachymetric measurements, made by himself in 1934, according to which the relative height of the highest crater is about 20 m. The crater walls are throughout low in relation to the circumference, and the group lies peripherally on a prehistoric lava flow, Ellidahraun, which has flown down the valley of the river Ellidaá to the shore. Near the shore this lava flow has covered a peat bog. According to a radiocarbon dating of the toplayer of this peat, carried out by Professor LIBBY of Chicago, its age (and accordingly the age of the lava flow) is 5300 ± 340 years. A considerable portion of this interesting crater group has unfortunately in the course of the last decade been dug away, the tephra being used as ballast for the roads and the aerodrome of the capital. Some of the most beautiful craters have already been removed.

Landbrotshólar. (1)

The most extensive crater group in Iceland is that in the district of Landbrot in Vestur-Skaftafellssysla. Situated on the lava flow underlying the great flow of 1783, it extends over the Landbrot plain E of this almost all the way to Skaftárós. An area of about 50 km^2 is here covered by thousands of craters and mounds bearing the common name of Landbrotshólar. To the W this crater field is approximately delimited by a line from Dalbæjarstapi towards the SSE to the outlet of the rivulet Syrlækur from the lava, but is continued westwards by a narrow belt along the Skaftá; a small lava field called Svíri, NW of Dalbæjarstapi, between the 1783 lava and Skaftá, is crowded with small craters; N of Skaftá and S of the Heidi farm lies a single crater of more than medium size, and single craters and small crater groups are projecting through the 1783 lava here and there along the Skaftá west of Svíri up to a place S of the Holt farm, and one crater group was, according to Rev. Jón STEINGRÍMSSON's description of conditions before 1783, covered by the 1783 lava SE of the abandoned Skál farm. A good deal further to the SW, S of the Ás farm in Skaftártunga, is the Hestalandshólar crater group (THORODDSEN, 1925, p. 72). In contradistinction to the crater groups in the Myvatn-Adaldalur area, cone-shaped scoria mounds without craters in their tops are very common in the Landbrotshólar crater group; some of the largest mounds, e. g. Blesalandshóll and Hánípa, NE and S respectively of Digriklettur, Sjónarhóll W of the Hraunkot farm, Háihóll S of the Kárstadir farm, and the large group W of that farm are of this form. The highest mound in the whole Landbrot group, Digriklettur (abs. height 61 m, rel. height ab. 20 m) is, however, a scoria-« Schweiss-Schlacken » crater. One very regular crater is Bóndhóll N of the Fagurhlíd farm, but generally the craters are of more irregular shape than at Myvatn and in Adaldalur. Hollow « Schweiss-Schlacken » cones of Arnarbæli type are common (e. g. Runkuskjól and Gránaskjól on the property of the Thykkvibær farm). Spheroidal bombs of the same type as in Laxárgljúfur have been found.

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(1) This description of Landbrotshólar is largely based on personal information received from my countryman Jón JÓNSSON, a student of geology at the University of Upsala, who was born and bred in the Landbrot district.

In some places the craters are arranged in long rows, e. g.

the Selhólar W of Digriklettur and Thykkvabæjartangi S of the Sydri Vík farm.

The Álftaver Crater Group.

In the Álftaver district, NW of the Hraunbær and Herjólfsstadir farms and S of the river Skálm, there is a crater group some km^2 in area which contains hundreds of reddish and black tephra cones (Pl. XV), some with, others without craters. They are mostly of regular shape, and generally speaking they are somewhat higher in relation to their circumference than at Myvatn and in Adaldalur. The largest are probably about 15-18 m high.

According to THORODDSEN, Landbrotshólar and the Álftaver crater group are situated on the same lava flow, which according to him derives from the great Eldgjá fissure N of Myrdalsjökull. THORODDSEN considers this enormous lava flow (about 700 km^2) to have been formed in historical times, about 950 A. D., basing this opinion on information from Landnámabók (1925, pp. 72-76). Preliminary tephrochronological investigations rather indicate that this lava was formed shortly before the colonization, but that question can only be definitely settled by further investigations.

The Thjórsárdalur Crater Group.

On both sides of Fossá, the river running through the valley Thjórsárdalur in S Iceland, a 1-2 km wide and 5-6 km long string of individual crater clusters (Pl. XVI) extends from Raudukambar down towards the ruined farm of Skeljastadir. As far as appearance is concerned, this group is very like that at Álftaver, and — as in Landbrot — there is here an occasional tendency of the craters to appear in rows. All these craters are situated on the lava flow that has come down through the Raudá river canyon. This lava is part of one of the Thjórsá lava flows, but we do not yet know for sure which.

Apart from these crater groups, small crater clusters and individual craters of similar type occur on several other lava fields in Iceland. P. HANNESSON, Headmaster of the Reykjavík

Secondary School, who knows Iceland better than perhaps any other now living man, has told me that such craters occur for instance on the following lava flows: Núpahraun in Fljótshverfi; here and there on Skaftárhraun (= the Laki lava flow of 1783), amongst them a fairly large group near Fljótsoddi just SW of Sídujökull; and one slightly smaller N of Blágil; on the lava flows N of Veidivötn, especially just W of Gjáfjöll; on a lava flow in Kverkfjallarani and in several places in the Ódádahraun area; on Hallmundarhraun N of Flosaskard; on Lambahraun eystra N of Hofsjökull, and in several places on the Reykjanes lava flows (including probably the scoriafield Raudimelur W of Straumur). Such craters also occur in several places on the Bárdardalur lava flow; on the Grímsnes lava flows and on the lava flow Raudhólahraun on the Melrakkaslétta near the Presthólar farm.

On the Genesis of the Crater Groups in Iceland and especially at Myvatn

Previous Researches and Views on the Genesis of the Crater Groups.

The first naturalist who mentions the crater gorups in the Myvatn area was the Icelander J. HALLGRÍMSSON, who spent the summer of 1839 in the Myvatn district, and wrote of the crater groups on the Myvatn islands: « These hillocks, called « hverhólar » are all old craters, which show that the fire has been raging at the bottom of the lake as well as in its surroundings » (HALLGRÍMSSON p. 10). The Danish geologist F. JOHNSTRUP, who went to Myvatn in 1876, considered that the lava flows in Laxárdalur came from the crater groups between Vindbelgur and Grímsstadir (1886, pp. 18-19).

JOHNSTRUP was in 1876 accompanied by a young Icelandic student, the subsequently famous volcanologist Th. THORODDSEN. In his paper on this journey (1878, pp. 116-120) nothing is said about the crater groups. In the summer of 1882 he again traversed Laxárdalur and the Myvatn district, and in his report on that journey he states that the Adaldalur lava flow is a result of prehistoric eruptions in the Laxárdalur crater groups (Raudhólar ?), while the lava flow in the southern part of Laxárdalur came from the crater groups round the outflow of Laxá from Myvatn (1884, p. 97; 1913-15, I, pp. 24-29, 279-296). He maintained that opinion even after his journey in the same neighbourhood in 1884 (1888, pp. 46-48), but in his classic monograph « *Island. Grundriss der Geographie und Geologie* » he spoke of what he calls « secondary craters » (*aukagígir*) or « hornitos » (*hraunkatlar*): « Wo die Lava über ein Moor oder einen See fliesst, saugt sie so viel Wasserdampf auf und wird dermassen gesättigt, dass sie hier von neuem eine lokale Ausbruchstätigkeit beginnt die lange Zeit anhalten kann, namentlich wenn der Lavastrom eine grosse Mächtigkeit besitzt. Nach der Abkühlung ist die Lava mit einer unglaublichen Menge roter Schlackenkegel bedeckt, die riesenhaften Maulwurfshügeln gleichen; zuweilen finden sich hier glasierte, aus dünnen Lavakrusten und Lavaklecksen aufgebaute Kessel oder inwendig hohle, hoch aufgetürmte Lavakegel . . . Hornitos und Schlackenkegel desselben Ursprungs finden sich in vielen Gruppen am Myvatn und im Laxárdalur ». (1905-06, p. 142). In his « *Lysing Islands* » he says of the Myvatn craters: « The craters and crater clusters W of the lake have not yet been examined to ascertain which of them are real craters, and which are secondary, which is moreover difficult to decide »; of the craters in Laxárdalur he says in the same work that « most of them are probably secondary » (1908-11, II, pp. 185-186). These must be regarded as THORODDSEN's last statements on this question. He had evidently changed his opinion on the genesis of the Myvatn-Adaldalur craters, but would not go as far as regarding them all as secondary.

THORODDSEN's accounts of his travels show that he arrived at the above opinion of the crater groups while travelling in Vestur-Skaftafellssysla in the summer of 1893, when he had the opportunity of visiting the crater groups in Landbrot and Álftaver. In the account published in the following year he describes the genesis of these crater groups in almost the same words as those quoted above with reference to the Myvatn craters (1894 a, pp. 68, 76; 1894 b, pp. 218-219). On the subject of the Landbrot craters he adds that they were probably formed when a shallow fiord was filled by the lava (1913-15, III, p. 117; 1905-06, p. 143). **THORODDSEN** was the first to conclude that the crater groups in Iceland might have been due to liquid lava coming into contact with ground water or striking open water (1). Nowhere does he give any fuller explanation than the above of the process.

In the first decade of the 20th century the volcanologists of Central Europe paid a great attention to the Myvatn crater groups as well as to the Raudhólar group at Ellidavatn, SE of Reykjavík. When W. v. **KNEBEL** was at Myvatn in 1905 and 1907 he studied the crater groups at Skútustadir and on the Myvatn islands, made a relief map of the Skútustadir group, and sketch map of Mikley and Hrútey. **KNEBEL** interpreted the Myvatn crater groups — and the Raudhólar group near Reykjavík — as « die bis zur Erdoberfläche emporgedrungenen Vorposten einer nicht tief unterhalb derselben stechengebliebenen grösseren Schmelzflussmasse » (1912, p. 152). He emphasizes that the craters are quite irregularly arranged and cannot be referred to any system of fissures. Myvatn was also visited by K. **SCHNEIDER** in 1905. He regards all the craters there as genuine explosion craters of the type he calls « Homate », to which he also refers Hverfjall (1905, p. 6; 1906, p. 10; 1907, p. 183 ff; 1911, p. 61 ff.).

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(1) **THORODDSEN**'s opinion on this point was probably influenced by the American geologist C. E. **DUTTON** (quoted by **THORODDSEN** in 1894, b, p. 219) who had explained some crater formations on Hawaiian lava flows visited by him in 1882 in the same way. I quote the following from **DUTTON**'s description of the Mauna Loa lava of 1868: « Following the main lava stream down to the sea, it spreads out in a wide field of aa. It is also pushed out into the ocean for the distance of quite a half mile, extending the area of the island just so much. At the end of the lava flow are three cinder cones, the origin of which is very curious interesting and suggestive. It appears that these cinder cones were formed by the contact of the lava with water. Their structure and general appearance are quite normal, corresponding in all respects with the cinder cones which are formed over ordinary volcanic vents. Here is an unquestionable instance of the formation of an ordinary volcanic crater by the adventitious contact of liquid lava with water. Nor are these cones by any means exceptional occurrences on this island. At the end of the great flow of 1840 from Kilauea, which strikes the ocean at Nanawale, in Puna, near the eastern angle of the island, three cinder cones were formed in precisely the same manner. Upon the north-western base of Hualalai, the eruption of 1801 produced a similar cinder cone at the water's edge. Along the western coast of the island, between Kailua and the south-western cape, a distance of 60 miles, may be seen a considerable number of small cinder cones standing upon the verge of the land, which from their appearance lead to the inference that they were formed in precisely the same way ». **DUTTON**, 1884, pp. 181-182, see also p. 151).

The well known German volcanologist H. RECK visited Myvatn and Askja in the summer of 1908 to investigate the drowning of v. KNEBEL in the Askja lake (Öskjuvatn) the previous summer. RECK has more than any other volcanologist stressed the significance of what he calls « areal eruptions » (1). RECK describes two types of these, viz. a) lava-producing « Masseneruptionen », in which plateaux basalts have erupted from clusters of vents in central areas instead of from fissures, and thinks the tertiary basalt plateaux of Iceland are largely built up of these, and b) « massenarme » areal eruptions.

RECK writes of the Skútustadir crater group: « Ich deute diese Krater als gewöhnliche regellos verteilte Durchschlagsröhren eines unweit der Erdoberfläche stechengebliebenen Lavapfropfen » (1910, p. 100). This crater group — and the Raudhólar group at Reykjavík, which RECK interprets in the same way — have since been appearing in volcanological literature as the prototype of such areal eruptions, but of Raudhólar RECK writes that they present « das typische Bild einer räumlich kleinen, stofflich massenarmen, bei gemischter Förderung an Intensität schwachen Arealeruption » (1930, p. 41). K. SAPPER, who undoubtedly visited Raudhólar during his travels in Iceland in 1906, mentions RECK's interpretation of Raudhólar in his « *Vulkankunde* », but does not express any opinion of his own on the genesis of the craters (1927, p. 74).

H. SPETHMANN, the third German geologist visiting Myvatn at that time (1907), holds a slightly different opinion than v. KNEBEL and RECK of the Myvatn crater groups. He writes of them: « Ich habe durch und durch den Eindruck gewonnen — exakt beweisen lässt es sich nicht, was in Natur der Sache liegt — dass es sich lediglich um Hornitos oder verwandte Erscheinungen handelt »; but to be on the safe side he adds: « Will man aber die fraglichen Gebilde nicht als Hornitos ansehen, so dürften sie vielleicht als die oberirdischen Köpfe einer grösseren Zahl von Gängen aufzufassen sein » (1909, p. 202).

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(1) RECK is using the designation in another sense that R. A. DALY, who by « areal eruptions » means the de-roofing of a batholith (DALY, 1911; 1933).

As said above, M. v. KOMOROWICZ mapped the Raudhólar group at Ellidavatn in the spring of 1907, spending some weeks in studying them. In his monograph on the group he designates the craters as « parasitäre », and explains their genesis as follows: « Es findet ein grosser Deckenerguss statt. Die Lava erstarrt, jedoch verbleiben in ihr kleine feurigflüssige Magmaherde, die vom Hauptschlote teilweise oder gänzlich abgeschlossen sein mögen, und deren Erstarrungsprozess aus irgend welchen Gründen langsamer vor sich geht. Durch irgend eine Ursache, vermutlich durch Gase oder durch Nachschübe des Magmas aus der Tiefe, kommt es bei diesen Magmaherden zu Ausbrüchen in kleinem Masstabe, und es bilden sich an der Oberfläche des bereits erstarrten Lavafeldes neue, kleinere Krater aus denen unter Umständen auch kleinere Lavaströme hervorgehen » (1912, p. 69). Later on he says that these craters « besitzen ihren Herd innerhalb der Eruptivmasse und sind Erkaltungsvorgängen innerhalb dieser zuzuschreiben » (op. cit., p. 191). v. KOMOROWICZ emphasizes the irregular distribution of the Raudhólar craters. The German seismologist A. SIEBERG, on the other hand, who visited Raudhólar in 1912, thought that he could in the general confusion trace an arrangement of craters along intersecting fissure lines, and considered the craters themselves real craters (1921, pp. 22-26).

The Danish geographer and volcanologist Niels NIELSEN, who especially studied volcanism in Iceland in 1923, 1924 and 1927, takes the same view as v. KNEBEL and RECK on areal eruptions, and mentions the crater groups at Myvatn and in Thjórsárdalur as examples of what he calls « mixed areal eruptions », i.e. both explosive and effusive, and the crater groups in the Veidivötn district as typical examples of explosive areal eruptions (1929, pp. 12-13, 16-18; 1933, p. 214 ff.).

F. v. WOLFF, who never visited Iceland, mentions four crater groups there, viz. Raudhólar at Ellidavatn, the Myvatn crater groups, the Veidivötn area and Raudhólar on Melrakkaslétta, which he, like **Reck**, classifies as areal eruptions (1921, pp. 890-891).

The Swiss volcanologist A. **Rittmann** visited the Myvatn district in the summer of 1937. Although he remained there only a few days, he and his collaborators made extremely effective use of their time. Their work included the mapping of some of the most important crater groups, and **Rittmann** gave the so far most complete descriptions of them. Considering the short time he had been there, his maps and descriptions are surprisingly good although far from exact in detail. As regards the genesis of the craters, **Rittmann** — approaching most closely the opinion of v. **Knebel** and **Reck** — considers that there has been a shallow magma reservoir or eruption sill underneath the whole area. The thickness of the overlying lava ranged from a few tens to a few hundreds of metres. Further, he thinks that the layer forming the roof of that sill broke, in which case the requisite energy for the eruptions may conceivable have been produced in two ways: a) by an almost explosive de-gassing due to reduced pressure in the underlying magma reservoir, or b) by the formation of steam

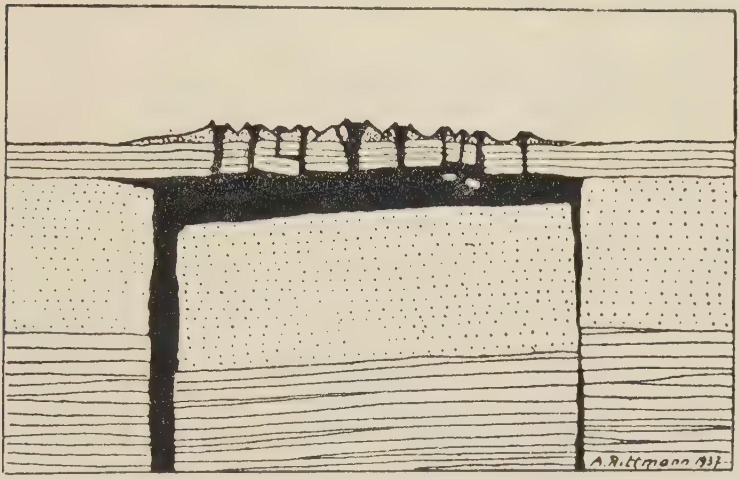

Fig. 12. - Schematic picture showing **Rittmann**'s conception of the genesis of the Myvatn crater groups. Black: Magma. Sparcely dotted: Glaciofluvial deposits. Striated: Basalt sheets. Closely dotted. Tephra.

when the magma contacted the superimposed, presumably water-logged layers (1938, pp. 10-19). His opinion is schematically illustrated in Fig. 12.

The Norvegian petrographer Tom F. W. BARTH, who also was in the Myvatn area in the summer of 1937, adopts without reservation RITTMANN's opinion of the genesis of the craters (1942, pp. 64-66).

The author's Conception of the Genesis of the Myvatn-Adaldalur Crater Groups

The crater groups of Iceland have, as will be seen from the above, been interpreted as real craters by most foreign scientists who have studied them. Icelandic geologists, on the other hand, have — although none of them has been directly engaged on this problem — since the days of THORODDSEN generally accepted the view that secondary craters may form in the manner suggested by him. But the acceptance in principle of THORODDSEN's hypothesis need not necessarily mean that all the crater groups in Iceland must be accepted as secondary, least of all craters as huge as the largest in the Myvatn area, and when I began investigating the Laxá lava flows in the autumn of 1946, neither I nor any other Icelandic geologist had any well founded opinion on the genesis of these craters. Already on my first reconnoitring trip, however, during which I found time to examine the secondary tephra layer at Laxárgljúfur and to compare the crater groups in Adaldalur with those in the Myvatn area, I reached a conclusion as to the genesis of these craters, which my subsequent finds have only confirmed. That opinion is, briefly, the following: *All the crater groups in the Myvatn area, Laxárdalur, and Adaldalur consist of pseudocraters* (1).

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(1) Instead of *Thoroddsen*'s term *secondary crater* (Icel. *aukagígur*) or *hornito* (Icel. *hraunketill*), I prefer the designation *pseudocrater* for craters of the Skútustadir-Raudhólar type. The term hornito should be confined to minor features like those originally described by A. v. HUMBOLDT as hornitos on the Jorullo lava flows from 1759 (1858, pp. 340-348), and depicted *in statu nascendi* on the lava flows of Parícutin (cf. SAPPER, 1910; 1920; 1927, pp. 165, 183, 214; MARTIN, 1949, Fig. 3). The boundary between pseudocrater and hornito is not sharp, however, and many of the pseudocrater groups contain samples of all intermediary stages between the two types.

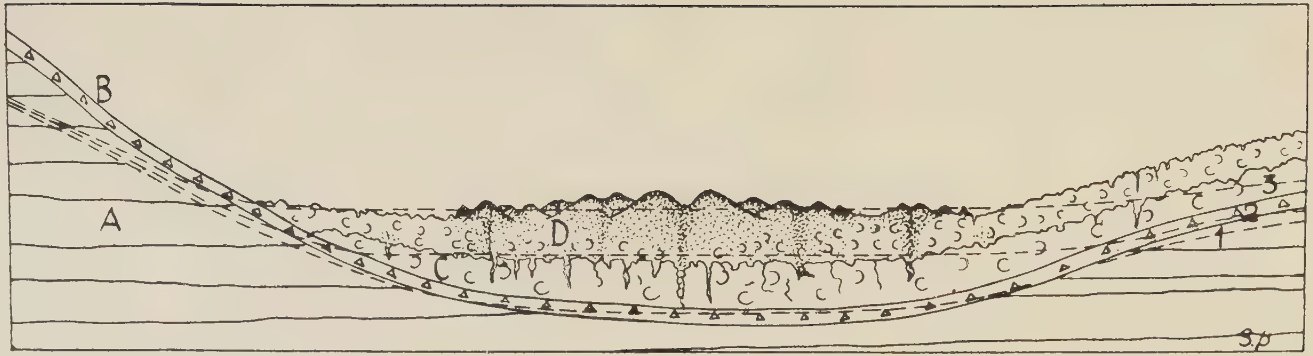

Fig. 13. - Schematic figure showing the author's conception of the genesis of the Myvatn crater groups. A: Bedrock. B: Ground-moraine. C: Older Laxárhraun. D: Younger Laxárhraun. Dashed lines indicate the ground-water level. 1: Before the emission of the older Laxárhraun. 2: Before the emission of the younger Laxárhraun. 3: Present ground-water level.

Such craters form when a lava flow wells forth over areas the surface layers of which hold plenty of ground water, e. g. mires, waterlogged sandur plains, or — as in the Myvatn area — lava fields where the ground-water level is high and all clefts and cavities are more or less filled with water, i. e. where water is shut in by the flowing lava and converted into steam. They can also form when lava flows into open water (2), *provided water is at the same time shut in by the flowing lava.* Fig. 13 illustrates schematically my opinion of the genesis of the Myvatn crater groups.

The proofs of the above conclusions are briefly the following:

I. The secondary tephra layer at Laxárgljúfur. — We have previously established the occurrence at Laxárgljúfur of what must be designated *a secondary tephra layer,* i. e. a layer of clastic ejecta that is not formed by a regular volcanic eruption — none such has ever occurred in Laxárgljúfur — but by explosive activities in a progressing lava flow. The question is then: what can have caused this lava, the sources of which lie at a distance of ab. 40 km., to be so explosively active that scoria and lapilli have been flung as far as 500 m to form a continuous tephra layer covering an area of about 0.7 km^2? This can be answered, if we consider the present conditions in Laxárgljúfur and reason out what would happen if another lava flow should come down through the canyon. As already said, the present lava surface is very pitted and porous, with large cavities, which may be filled by penetrating water. If a lava flow were now to run down the canyon, it would shut in underneath it a good deal of water, which the heat of the moving lava flow would eventually convert into steam. Similar condition must have existed when the younger Laxá lava flow came down, as this was of course running over the older Laxá lava and the river Laxá, which was then as now flowing through the canyon. The conclusion is therefore that *the younger Laxá*

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(2) G. A. MACDONALD has stated that tephra cones of the type described by DUTTON in the main are formed where aa-lava flows into the sea and not where pahoehoe enters it (1944, p. 181). With few possible exceptions the same seems to be the case in Iceland.

lava flow has become explosively active and formed this secondary tephra layer at Laxárgljúfur when, on its way through the canyon, the water shut in underneath it was converted into steam. I do not think any other explanation is possible. This also provides a reasonable explanation of why the younger Laxá flow has formed a continuous tephra layer, while the older lava has only thrown out scattered scoria. This cannot be due merely to the canyon's being then about 10 m deeper; the older lava must have been less explosively active, which in its turn is explained by the circumstance that there was less chance for the running lava to enclose water then than when the younger lava came down. The older lava did not here flow over a lava river bed, but over a « normal » river bed. This was presumably rather uneven, there would be waterfalls with pools at their feet, as the river ran an obsequent course across layers of differing hardness, but much less water must nevertheless have been shut in by it than by the younger lava later on.

The formation of the secondary tephra layer at Laxárgljúfur does not differ in principle from the formation of pseudocraters. The material, mainly scoria and lapilli, is exactly the same in both, and the tephra layer is more by way of being the distal parts of pseudocraters. In the Laxá Canyon such craters may possibly have started to form on the lava stream at the same time as the tephra layer, but been destroyed *in statu nascendi* by the continued flow of liquid lava.

II. The morphology and geographical distribution of the craters. — What is perhaps the strongest argument in favour of all the craters in the Myvatn-Laxárdalur-Adaldalur district being pseudocraters is in my opinion obtained by not considering the Myvatn district by itself, as most students have done, but to look upon all the three said districts as one whole. Take the largest craters in the Myvatn district, e. g. the craters on Belgjarnes; it certainly seems improbable, and almost absurd to consider them pseudocraters, and one naturally asks whether they are not after all real craters, though others may be pseudocraters. But the whole problem changes its aspect if we regard the three districts as one. There are, as I said before, some craters on the older Laxárhraun in Adaldalur, and on the younger lava right from its northernmost parts in Adaldalur to the eastern shore of Myvatn. There is no morphological difference between the craters in any of these districts. Every crater group consists of large and small craters of all sizes, from the smallest to the largest. I see no possible way of differentiating in each crater group the smaller pseudocraters from larger that might be assumed to be real craters, but must, like most students of the Myvatn crater groups, regard each crater group as a monogen formation. But neither can I find any reason to think that the crater groups in Laxárdalur and Adaldalur should be genetically different from those in the Myvatn area, as there is no way of classifying the craters in these areas according to their sizes. The largest craters in the Myvatn area are certainly larger than any crater in Laxárdalur or Adaldalur, but the largest craters in the latter areas, e. g. those in the Raudhólar group in Laxárdalur, are larger than most of the craters in the Myvatn area. It must therefore be assumed that all craters on the Laxá lava flows are genetically alike. But in that case none of them can be real craters formed as assumed by RECK, RITTMANN and others, for that would mean that magma had penetrated at little depth not only under all that part of the Myvatn area where there are crater groups — i. e. not only the central part but all the way to lake Sandvatn both N and S of Vindbelgur and to the country SW of Grímsstadir — but also under the whole Laxárdalur and Adaldalur areas right up to Skjálfandi Bay. The question also arises: If the craters are real craters, formed as assumed by the said students, how can we explain the fact that — although occurring in several places, e. g. in Adaldalur, right out to the extreme margins of the two Laxá lava flows — they do not occur anywhere outside the area covered by them, and why are the great majority of the craters concentrated to the younger flow? To my mind, the only reasonable explanation is that the crater groups are genetically associated with the said lava flows. The reason why the younger Laxárhraun is so exceptionally rich in pseudocraters — far more so than the older flow, although both are of almost exactly the same chemical composition — is the same as the reason why the younger lava flow has formed a heavy secondary tephra layer in Laxárgljúfur while the older lava has only thrown out scattered scoria there, viz. that much more water was there to be shut in when the younger lava was flowing than when the older flow came down; conditions were in fact exceptionally good. These conditions were created by the older Laxárhraun, which dammed the Myvatn depression and formed the first lake Myvatn. The ground-water level in the district was consequently raised, establishing conditions like those now determining the ground-water level in the surrounding lava fields (cf. Fig. 13). The younger Laxárhraun came down over such a district, where much water could be confined beneath it. I have said above that the craters are largest in the central part of the area and smaller towards the peripheral parts of the lava, probably because the central parts of the lava were thicker, thinning off towards the margins. Similar conditions obtained at the northern end of Laxárdalur and on the plain of Adaldalur after the covering of these areas by the older Laxárhraun, which was then saturated by the waters of Laxá. The younger lava subsequently came down on top of this. Typically enough, there are no pseudocraters on the older lava except in its northernmost parts, where it had apparently covered a watery « sandur » plain, as had the lava in Landbrot and Álftaver. Nor do the lava flows in the Myvatn area that are older than the Laxá lava flows contain any pseudocraters, which is quite natural, seeing that the conditions precedent to the formation of such craters in this area were only established by the older Laxárhraun.

III. The texture and physical-chemical properties of the crater material. — I have examined sections of a number of craters in the Myvatn area as well as in Laxárdalur and Adaldalur, and found the lapilli and scoria in all of them to be of the same felspar-porphyritic texture as in the Laxá lava flows and the secondary tephra layer in Laxárgljúfur. As will be seen from Table I, the scoria from the Skútustadir group, and from the secondary layer in Laxárgljúfur, are of very similar chemical composition. The Fe_2O_3 contents of both are, though rather low, slightly larger than those of the parent lava, which may indicate that some oxidation has taken place when the pseudocraters were formed. This similarity in texture and chemical properties is not *per se* any proof that these are pseudocraters, as the magmatic products of that time are of nearly the same texture everywhere in these areas. But if the craters had been real explosion craters one would expect to find, among the clastic ejecta of which they are built up, fragments of the « roof » of the presumptive magma hearth, i. e. xenoliths, more especially as such fragments are common in the adjacent real explosion craters Hverfjall and Lúdent. I have found no such fragments, nor are such fragments mentioned in any previous descriptions of the craters in question.

I may also mention here a recent statement by the Icelandic physicist T. EINARSSON, that while scoria from real craters are light and exclusively spongy, those that build up pseudocraters are denser and inhomogeneously vesicular, but not spongy; he further says that the scoria in Raudhólar at Ellidavatn and in the Skútustadir group are of the latter type (1949, pp. 11-15). I, too, have found that the scoria in pseudocraters often are denser than in real craters, but I have the impression that the variations in density and porosity are so wide in both types of craters, and the transitions between them in this respect to diffuse that these properties can hardly be considered reliable criteria. Nor has EINARSSON in my opinion yet produced sufficient evidence in support of his statement that pseudocraters can in this way be definitely differentiated from real craters. His hypothetical assertion is, however, supported by G. A. MACDONALD, who has stated that the grains of vitric ash in the littoral cones on the Hawaiian lava flows differ from the vitric ash produced by lava fountains at the source of the flows in being much less vesicular (1949, p. 72). And EINARSSON's assertion leads to the same conclusion as I have drawn regarding the genesis of the Myvatn crater groups.

IV. The age of the crater groups. — In order to determine the age of the crater groups I have examined the tephra layers in soil profiles in several of their craters

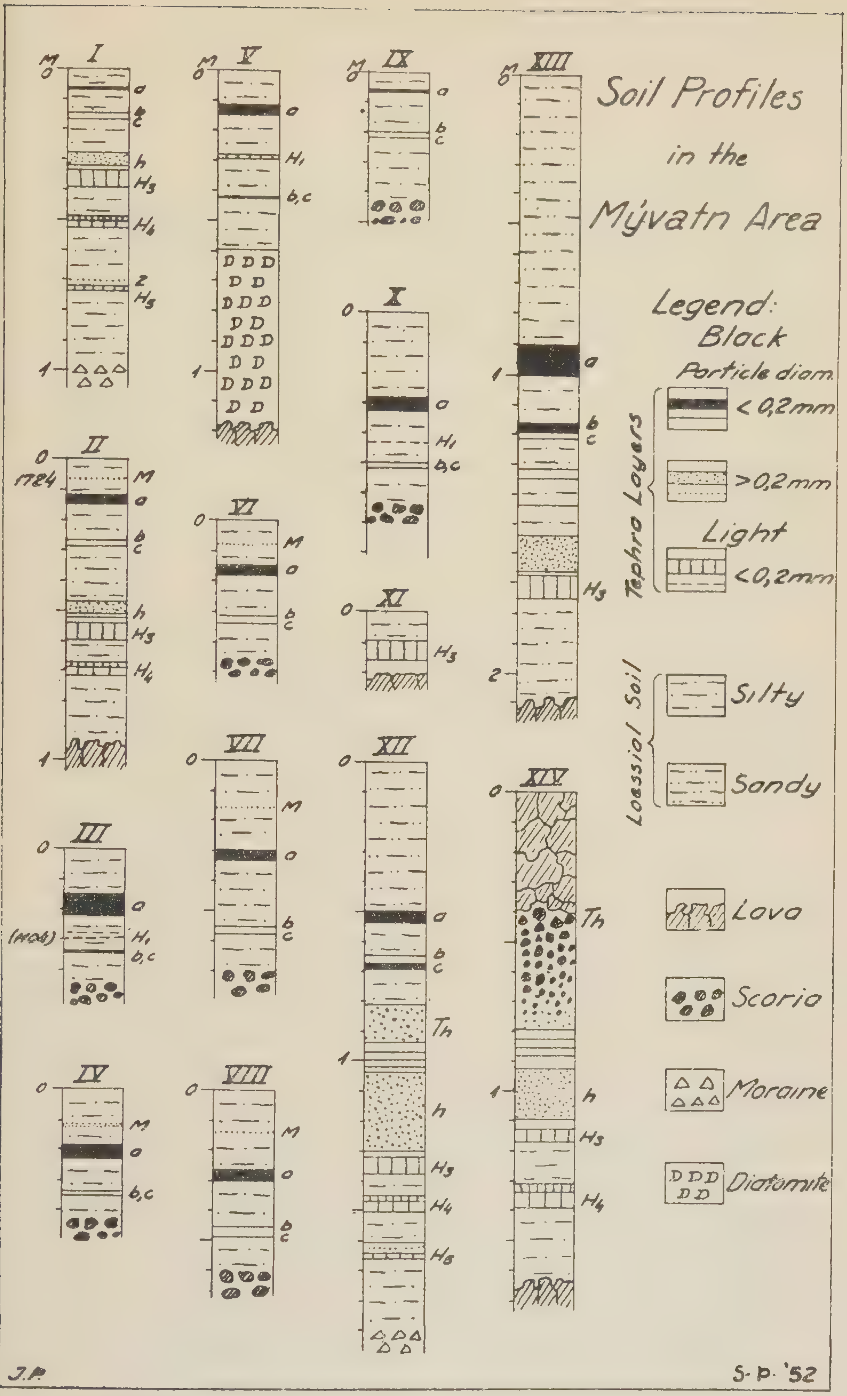

Fig. 14. – Soil profiles in the Myvatn area: I: Soil cover in ground moraine just W of Grímsstadir farm. II: Lava on the Slúttnes island. III: Inside a crater in the crater group Grímsstadaborgir. IV: Inside the crater Vesturhöfdi on Belgjarnes. V: A depression in the younger Laxá lava W of Haganes farm. VI: Inside a big crater in the Skútustadir crater group. VII: Inside the crater Midhver on Geitey. VIII: Inside a crater on Hrútey. IX: Inside a crater on Mikley. X: The younger Laxá flow just N of Kálfaströnd farm. XI: A window in the younger Laxá lava E of Grænavatn farm. XII: Hillock (Kálfastrandarholt) surrounded by the younger Laxá flow. XIII: The older Laxá lava in the mouth of Seljahjallagil. XIV: Lava field 30 m E of Threngslaborgir.

(Fig. 14). I did not find the layer H_3 anywhere on the craters situated on the younger Laxárhraun, nor on the lava itself, but the older lava is covered by that layer, which is also found in its craters. There are no signs of the craters being older than either of the lava flows. The same tephra layers are on the other hand found in profiles inside the craters of the Myvatn area as on the surrounding lava (Fig. 14, profiles III-X), and these profiles are upon the whole very much alike. Although these facts do not warrant any exact age determinations they greatly favour the view that the craters are all of the same age as the surrounding lava, and no contradicting tephrochronological data have so far been discovered.

The above arguments must suffice to motivate the opinion I have submitted above on the genesis of the craters. I will not enter here on any physical-chemical explanations of how the absorption of steam can activate liquid lava. I will, however, mention some observations that seem to be of interest in this connection.

I have already mentioned the very striking regularity of many pseudocraters, without any trace of deformation, which is clearly evident from the maps and photographs in this paper. To my mind these regular craters cannot have been formed as early as when the lava first welled forth over the watery ground — in which case they must have been deformed in *statu nascendi* while the lava was still flowing — but apparently not until the movement of the lava had almost ceased, at least on the surface. This is most clearly evident in the Raudhólar group in Laxárdalur. In welling down through the N part of Laxárdalur the lava was slightly obstructed by the relatively narrow S mouth of Laxárgljúfur, and formed there a kind of elongated lava lake ab. 10 km in length. A little later, when a smooth, ab. 30 cm thick crust of *helluhraun* type had formed on this lake its level was lowered, the crust broke and the lava flowed as a river between lava terraces 3-4 m high, where the river Laxá is now running (Pl. XVII). The crater group Raudhólar runs right across the eastern terrace and must therefore presumably be younger than that terrace.

Finally it may be mentioned that in one crater of the Skútustadir group, and in the Margrétarhóll crater in Adaldalur, I found rough-edged fragments of felspar-porphyritic lava coated by 1-2 cm of lava which had obviously been fluid when the fragments were embedded in it. These fragments may possibly have come from the underlying older Laxá lava, but may also have belonged to a coagulating crust already formed on the younger lava before the pseudocraters were formed.

The Genesis of other Crater Groups in Iceland

As previously said, THORODDSEN considered that the craters in the E Landbrot (Landbrotshólar) and the Álftaver group are pseudocraters, and I do not see any other possible explanation of their genesis. There have been no postglacial volcanic activities at all in the low plains of Vestur-Skaftafellssysla, and both these crater groups, as well as Hestalandshólar, are in the same way the results of lava flows — which according to THORODDSEN derived from Eldgjá — crossing watery ground, mainly waterlogged sandur plains. The crater rows in the Landbrotshólar group may possibly be situated along pre-eruption river beds on these plains. As regards the age of these lava flows see p. 23 above.

The craters in the Thjórsárdalur group are certainly also pseudocraters. The parent lava (Thjórsárhraun) seems here to have flowed partly across marshy ground, partly across pre-existing river beds in the valley. This crater group is certainly a few thousand years old but as said on p. 23 we do not yet know which of the Thjórsá lava flows is its parent lava.

The much described Raudhólar group near Reykjavík also in my opinion consists of pseudocraters in the pre-historic Ellidahraun lava. This is not necessarily contradicted by the fact that the accidental ejecta include some blocks of the underlying doleritic lava, which may be loose moraine boulders thrown up by the explosive activities that built up the craters, or embedded in the flowing lava; the explosions may even have carried away small fragments of the subjacent doleritic lava layer. The Raudhólar craters on the peninsula Melrakkaslétta in northern Iceland, which RECK (1930, p. 44) and after him

v. WOLFF (1931, p. 890) have given as examples of areal eruptions, are on the other hand not pseudocraters but — as far as can be judged from a photograph taken by ERKES (1911, Fig. 6) and THORODDSEN's description (1913-15, III, pp. 354-355) — a slightly irregular crater row, i. e. the result of a fissure eruption. But on the lava flow (Raudhólahraun) emanating from this crater row there are, as pointed out above (p. 24), a number of pseudocraters near the Presthólar farm.

The other crater groups mentioned on p. 24 are in my opinion most likely also pseudocraters.

In the Veidivötn area SW of Vatnajökull NIELSEN has described a group of 17 craters in a narrow belt of about 1 km^2 on the plain on the S shore of lake Litlisjór. He characterizes these craters as « an example of the form of volcano that is called the explosive areal eruption » (1933, p. 42 and Fig. 11). He also mentions some other small « areal eruptions » in the Veidivötn district. Personally, I have not had an opportunity of visiting this district, but I have several times flown over it at low height, and it gave me the impression that on the whole its volcanism is conspicuously linear and that its « crater groups » are not the result of areal eruptions *in sensu strictu*.

Concluding remarks.

All the crater groups in Iceland may thus in my opinion be deleted from our volcanological textbooks as examples of areal eruptions, and should instead be quoted as examples of pseudocraters. Personally I doubt if any crater group on the earth is due to areal eruptions and anyhow it may be regarded as certain that pseudocraters occur outside Iceland. DUTTON's interpretation of littoral tephra cones on the Hawaiian lava flows has already been mentioned and such cones have later been observed there *in statu nascendi* (JAGGAR, 1919, 1926). The crater groups described by STÜBEL from the Diret-el-Tulul lava field in Syria, which he interpreted as parasitic and RECK as examples of areal eruptions (STÜBEL, 1897, p. 359 ff.; RECK, 1930, pp. 37-38), may well be pseudocraters, and so may those of the Kissongo crater group in E Africa described by RECK (1930, pp. 32-34). The « lava blisters » at Byaduk in Victoria, Australia, described by SKEATS and JAMES (1937, pp. 245-278) seem to be small pseudocraters. The scoriaceous cones on the surface of a basalt lava flow in Ascension island described by DALY (1925) might be pseudocraters of the Icelandic type. Probably, however, this type of crater is more common in Iceland than in any other volcanic area, simply because the conditions precedent in the formation of pseudocraters have in recent times been more favourable in Iceland than anywhere else. The volcanic area of Iceland has in postglacial times been more characterized than any other area by eruptions of basalt flows covering enormous areas, which on account of the extensive plain and humid climate of the country have spread over marshy grounds, *sandur* plains, and other parts rich in ground water. The pseudocrater group may therefore with some reason be designated a specifically Icelandic phenomenon, which partly explains why volcanologists with experience of other volcanic areas have been unwilling to accept THORODDSEN's explanation of the genesis of these crater groups.

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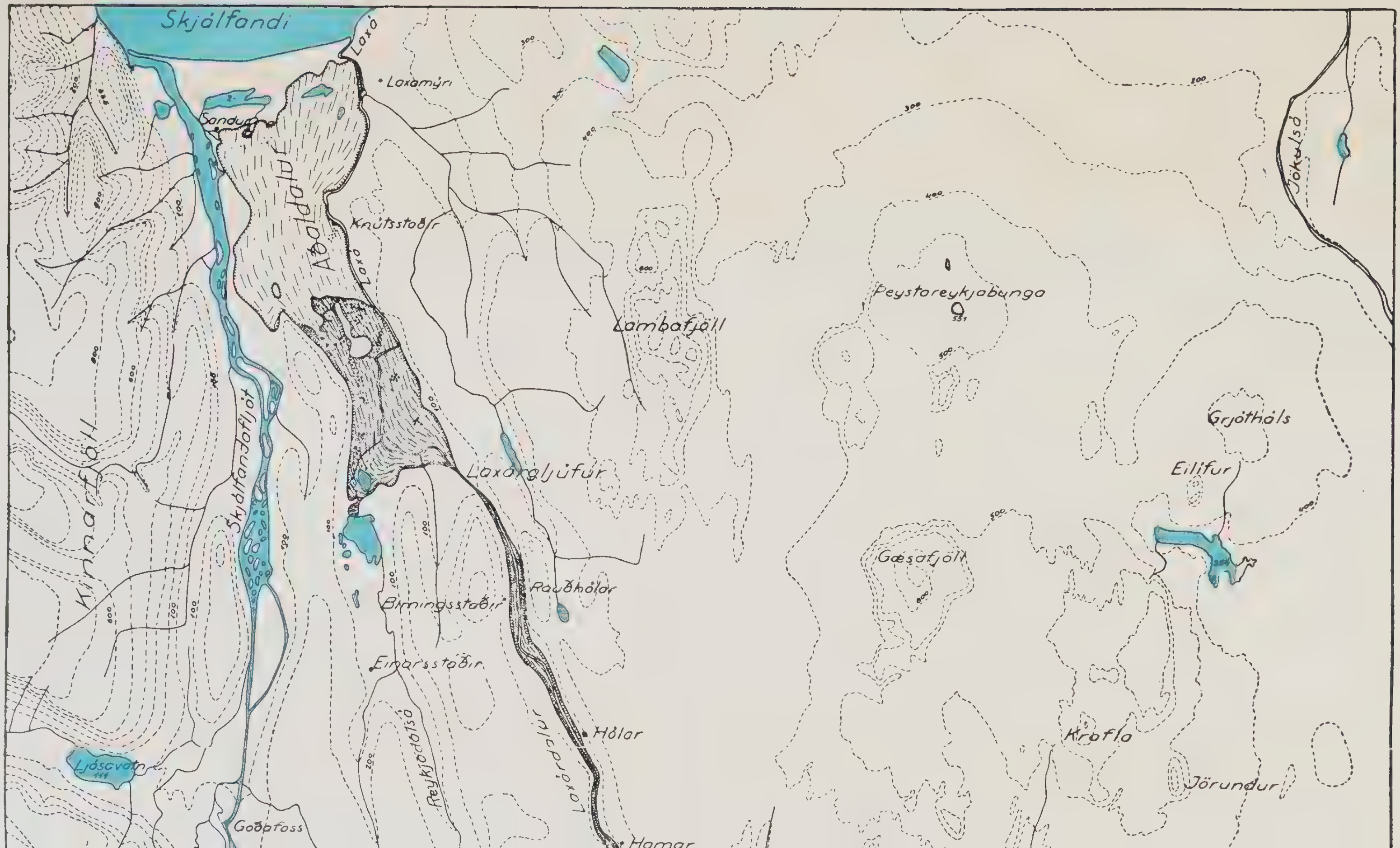
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Laxárgljúfur
Þeystareykjabunga
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Jökulsá
Grjótháls
Eilífur
Gæsafjöll
Rauðhólar
Birningsstaðir
Einarsstaðir
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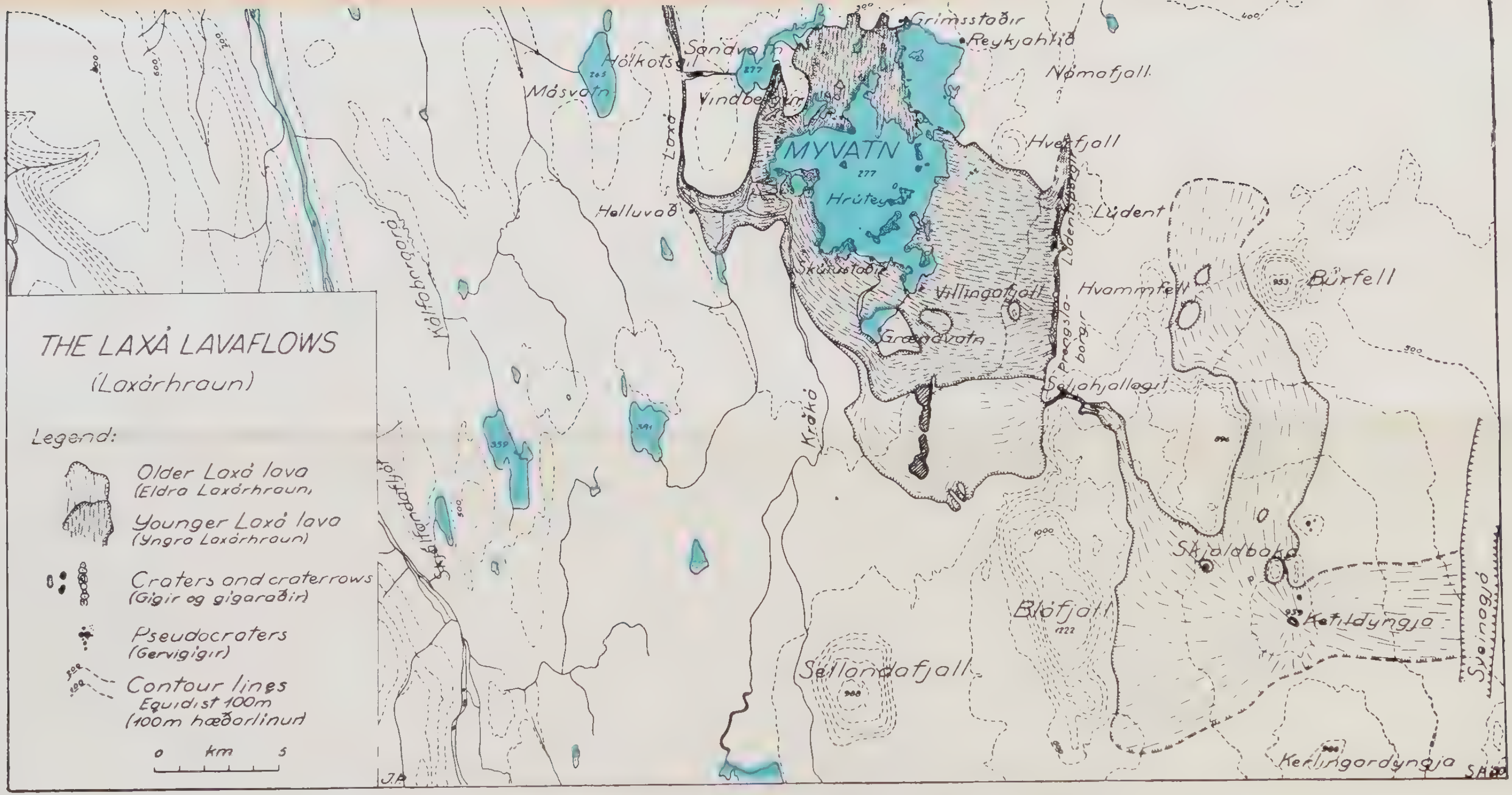
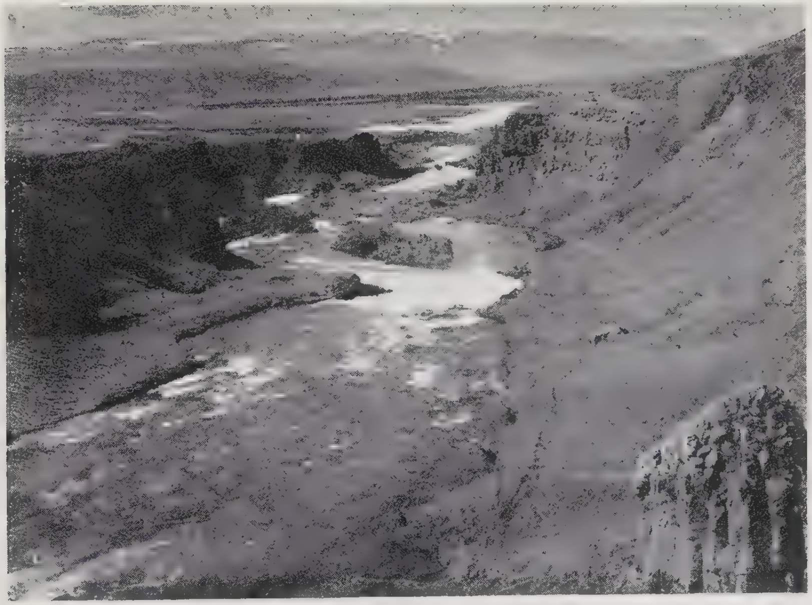
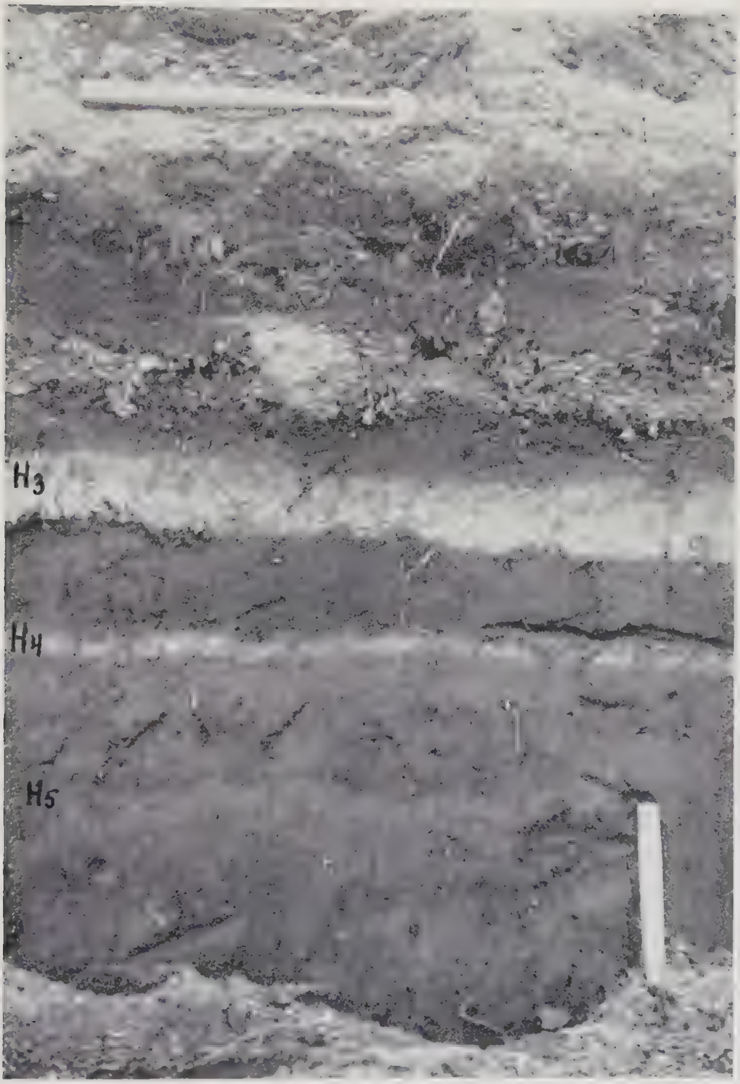


Map showing the extent of the Laxá lava flows according to the author's investigations.



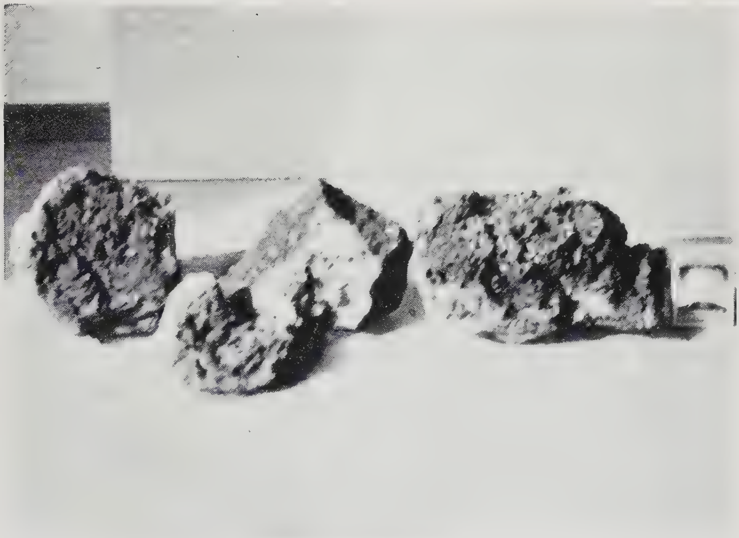
The N part of the Laxá canyon, from the S.

Photo: E. SIGURGEIRSSON.

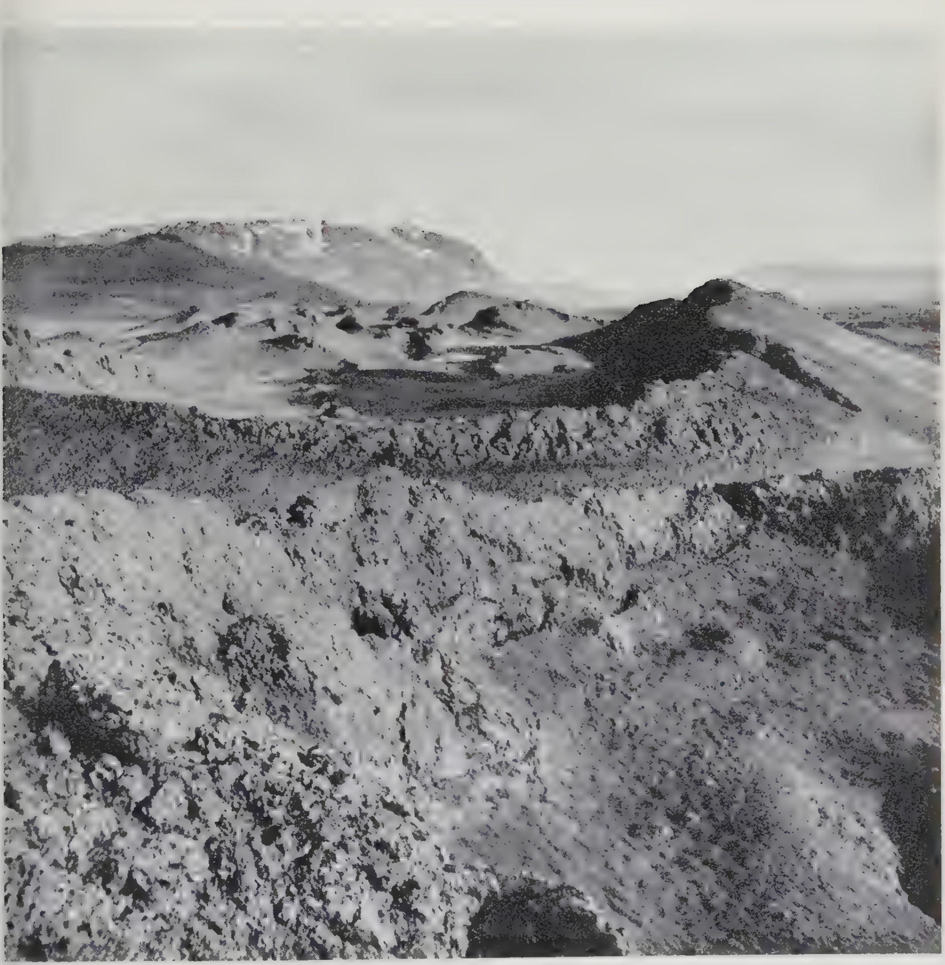


Soil profile at Laxárgljúfur (IV on the map Fig. 2), showing the tephra layers H_3-H_5 and the scoria-lapilli layer above H_3.

Photo: S. THORARINSSON 1949.

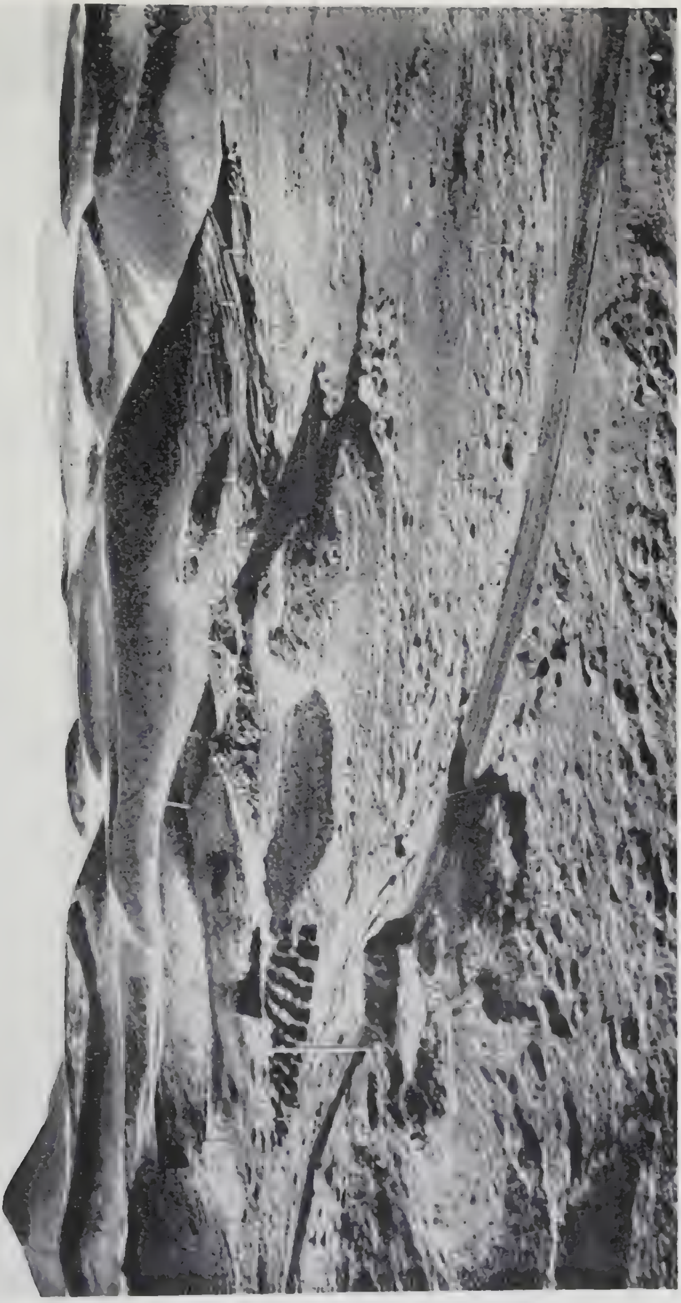


Bomb fragments from the secondary tephra layer at Laxárgljúfur.
Photo: S. THORARINSSON 1950.



The central part of the Threngslaborgir crater row, from the N.

Photo: S. THORARINSSON 1950.



The southwestern part of the Skútustadir crater group, from the SE.

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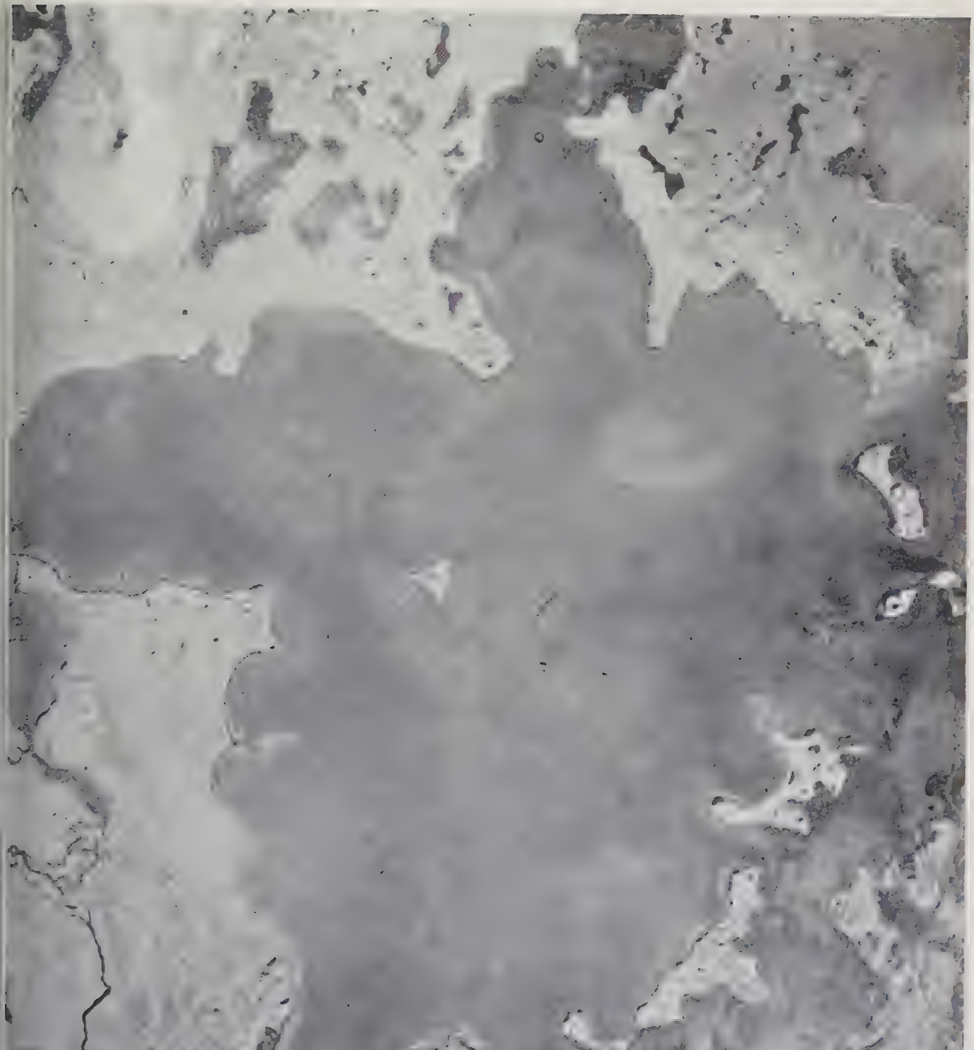
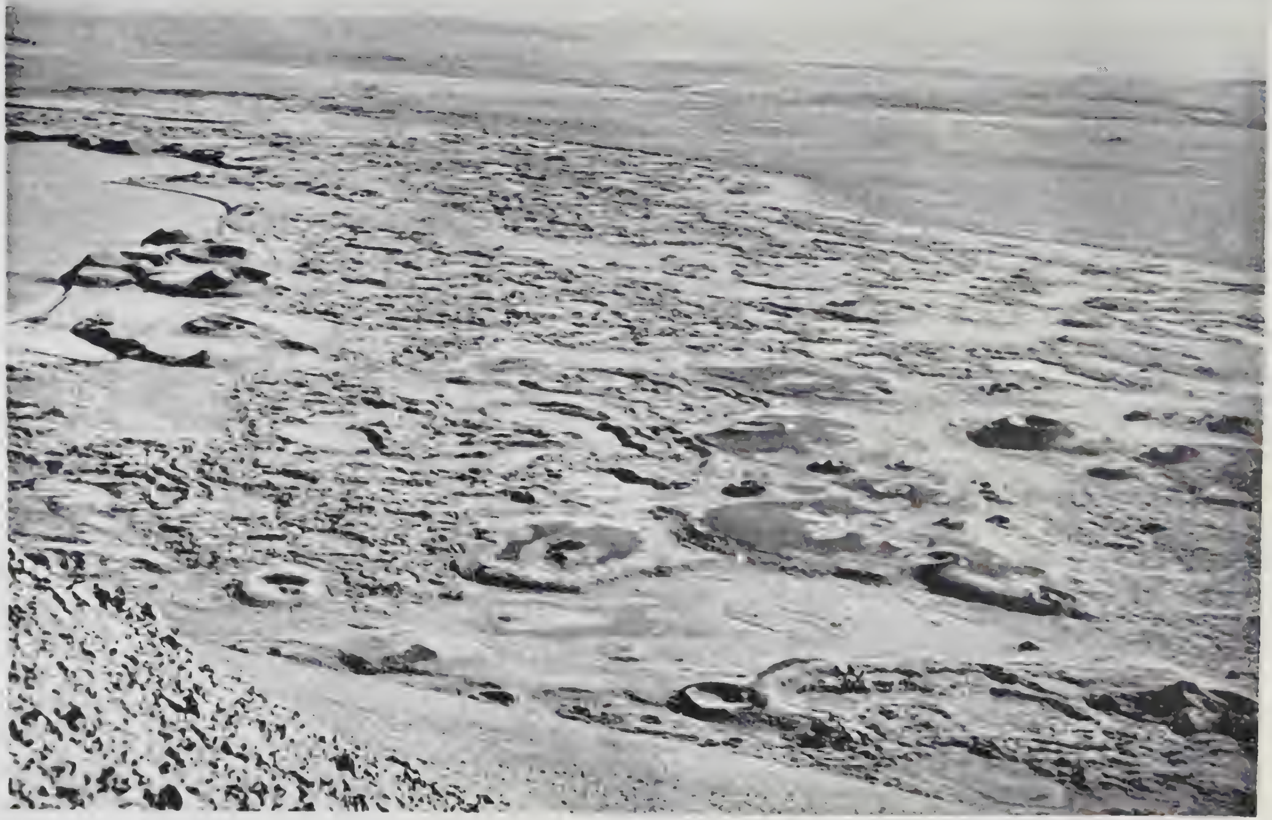
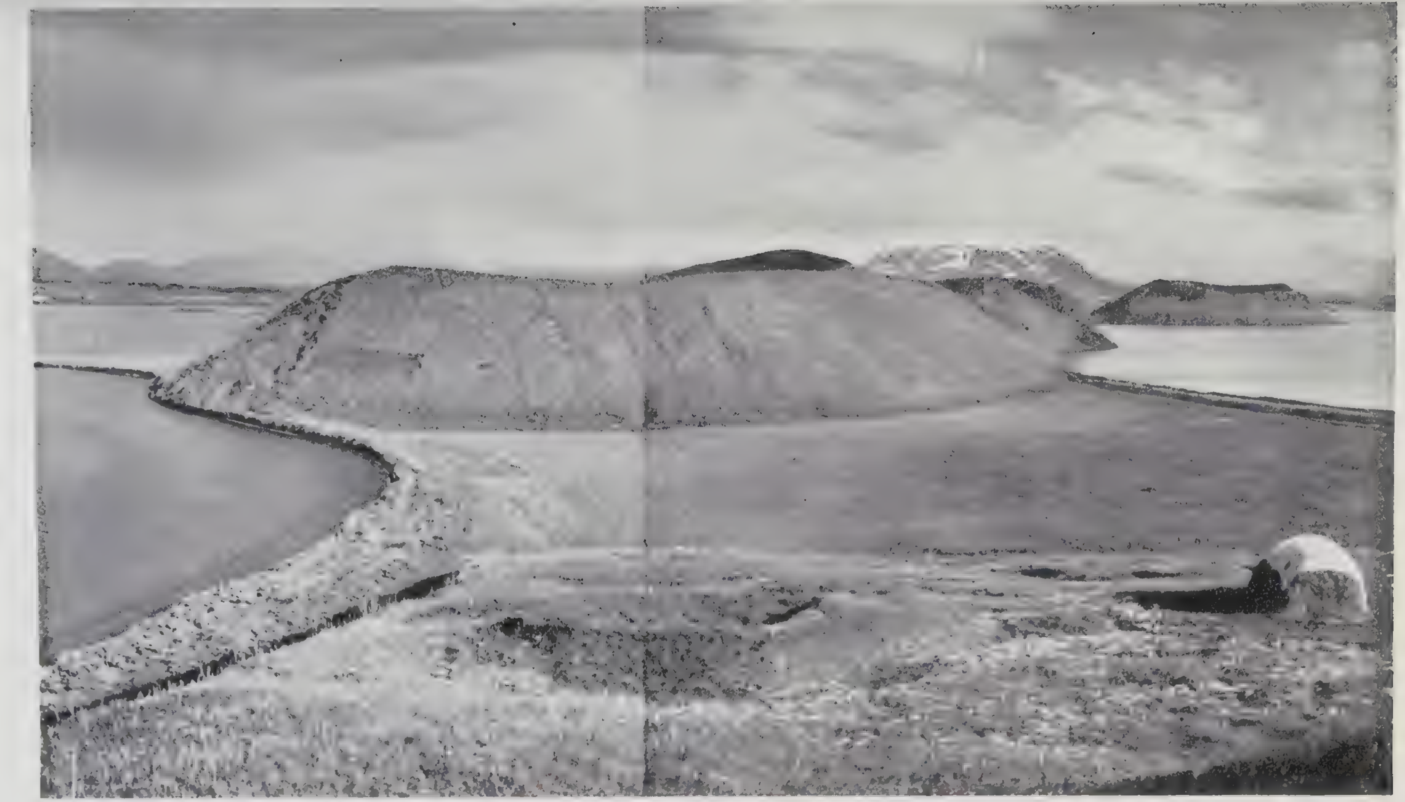


S part of Lake Myvatn. Aerial photo taken by the U. S. Air Force. Reproduced by the permission of the National Research Council of Iceland. Approx. scale 1:50.000. Cf. the map Fig. 5.



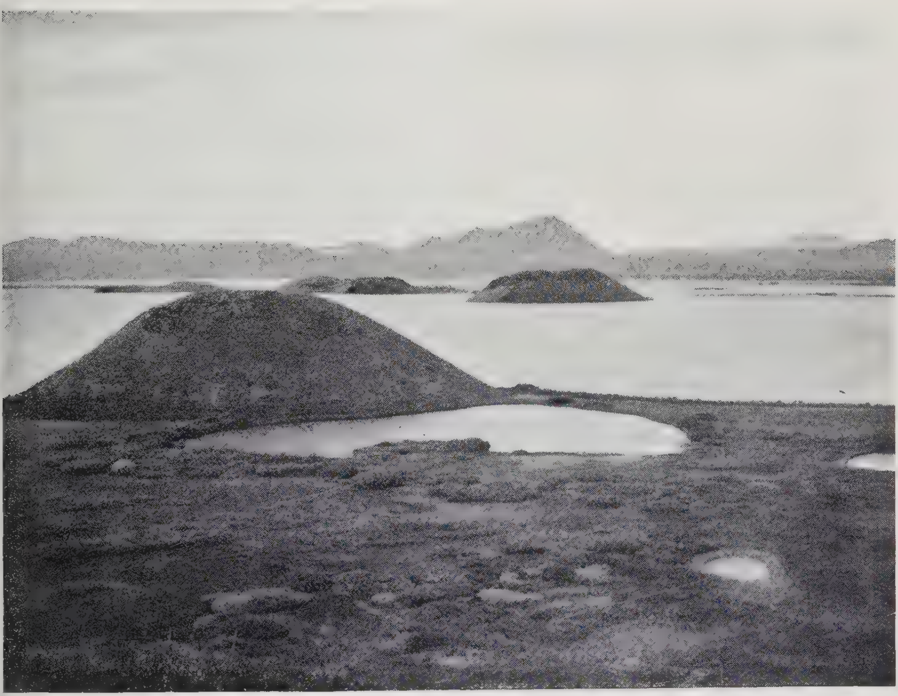
View from the southern slopes of Mt Vindbelgur (cf. the map Fig. 5) to the SSW over the Younger Laxá lava (between Vindbelgur and the outflow of the river Laxá) and its crater groups. The nearest crater group at the lake shore is Skútustaðahólar

Phot. Bj. Björnsson [illegible]



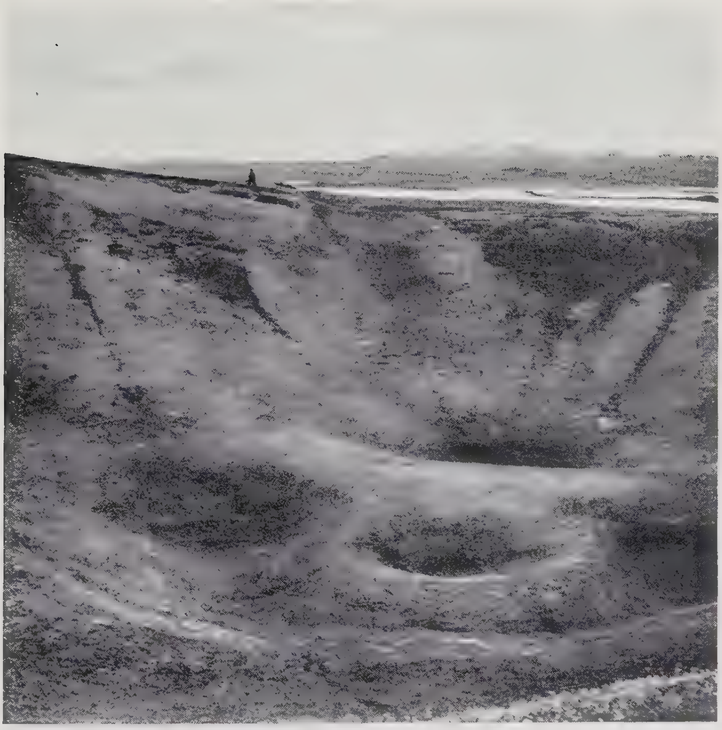
The crater Stórihver on Geitey, the northernmost of the three large craters on the island. Looking S. (cf. the map Fig. 9)
The Háey crater is seen to the right of Geitey.

Photo: S. THORARINSSON 1950.

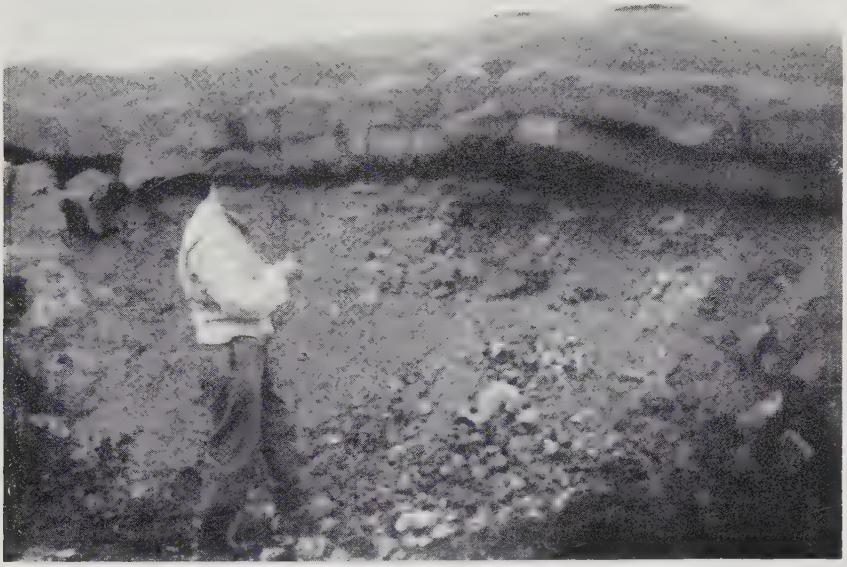


The NE-most crater on Hrútey. Locking NE. Behind the crater is Geitey and (to the right) Háey.

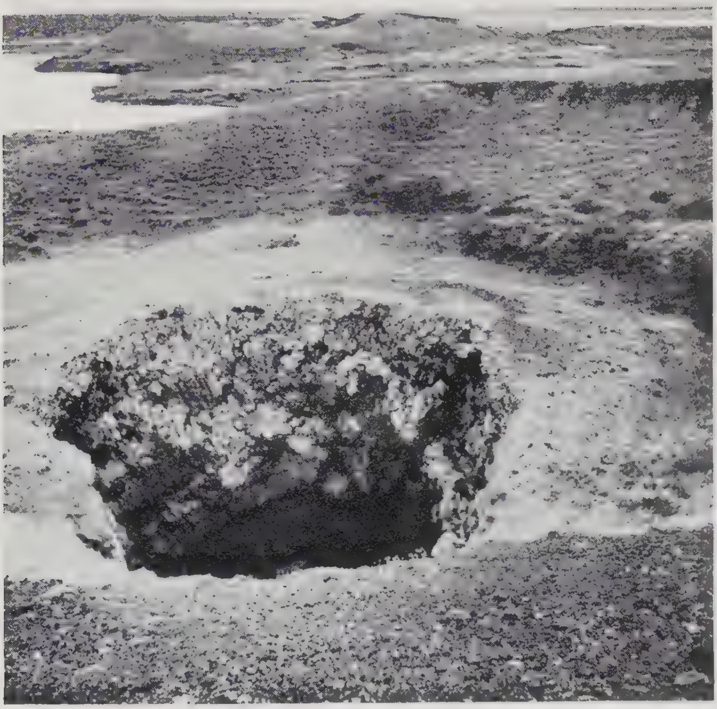
Photo: S. THORARINSSON 1952.



The inside of the crater Austurhöfdi on Belgjarnes. (A man is standing on the crater rim).
Photo: S. THORARINSSON 1950.

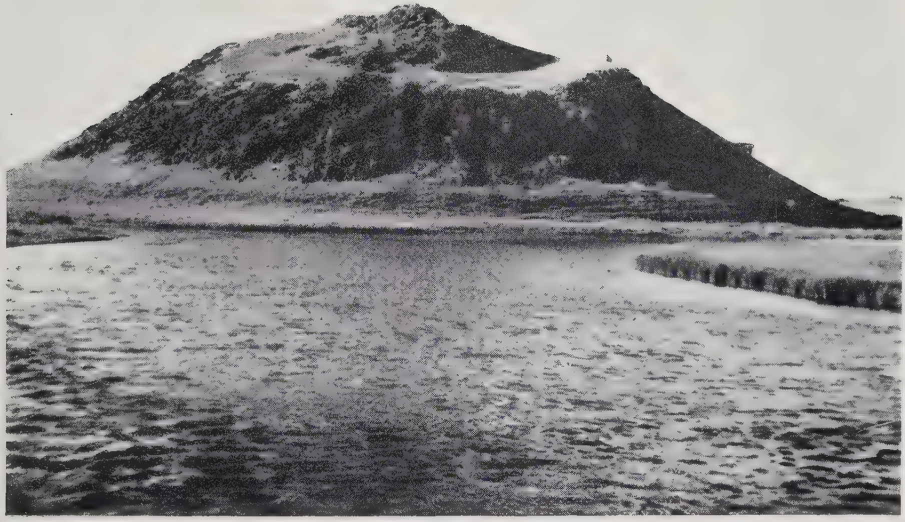


Slightly domed lava on a subjacent scoracieous material. Younger Laxárhraun 1.5 km WNW of Skútustadir farm. Photo: S. THORARINSSON 1949.



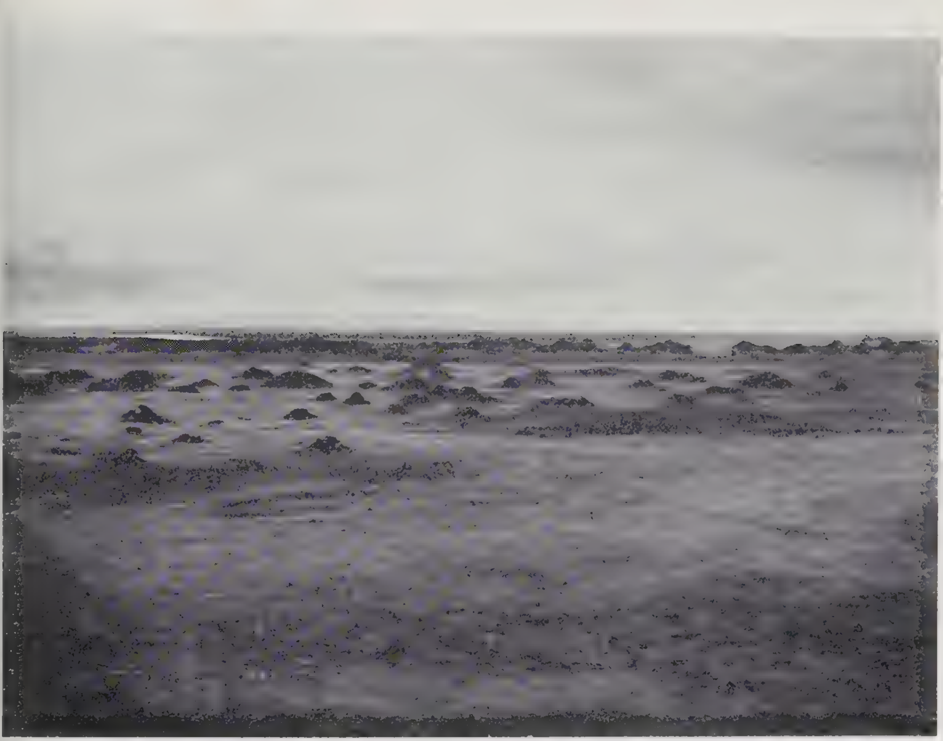
The Víti crater in the Arngardshólar crater group. (cf. Fig. 10). In background the crater group Gardshólar.

Photo: S. Thorarinsson 1950.



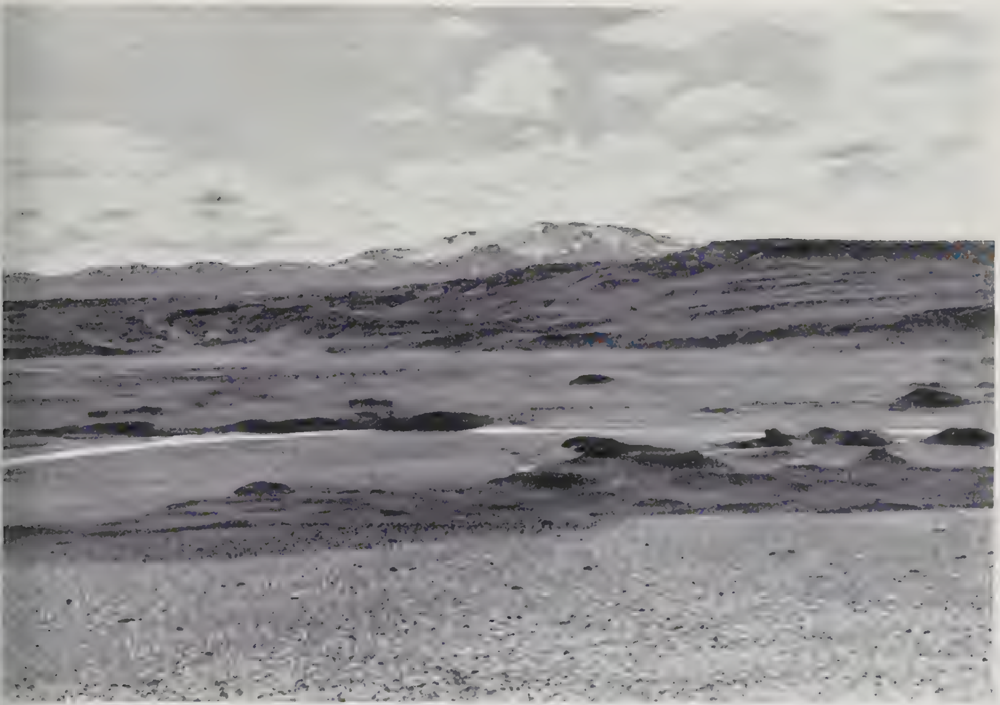
Arnarbæli, a hollow « Schweiss-Schlacken » cone, 15 m high. (A cow is standing on the right slope).

Photo: S. THORARINSSON 1951.



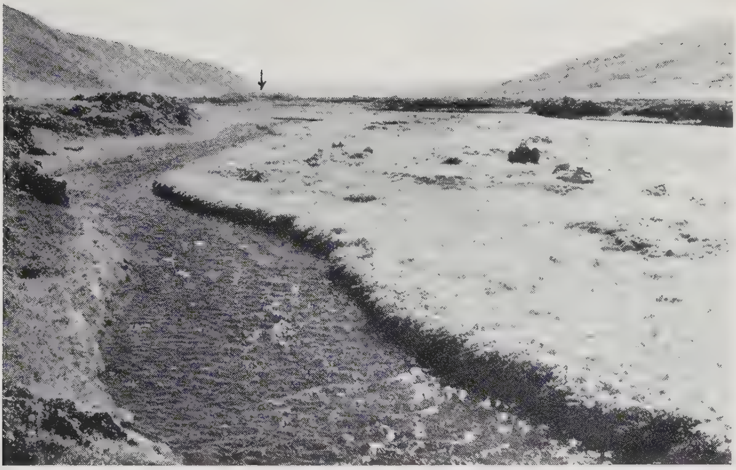
The crater group in Álftaver, from the SW.

Aerial photo: S. THORARINSSON 1950.



Craters along the Fossá river in Thjórsárdalur. (In the background Mt. Hekla).

Photo: S. THORARINSSON 1939.



Lava terraces in Laxárdalur between Laxárgljúfur and Raudhólar. Looking S. The arrow points to the Raudhólar crater group.

Photo: S. THORARINSSON 1950.

A. RITTMANN
(Alexandria)

Magmatic Character and Tectonic Position of the Indonesian Volcanoes

(With 2 figs.)

The relation between the chemical composition of magmas and the geological structure of the region in which they occur is one of the most important facts stated by petrologists. It can be expressed by the general rule: calc-alkaline (« pacific ») magmas are poured out by volcanoes situated in folded active orogenic belts, while alkaline (« atlantic ») magmas occur in non-orogenic faulted regions. The potassic (« mediterranean ») magmas are generally limited to subsiding hinterlands of active orogenic belts.

The character of the different magmatic series can be more or less pronounced, and all kinds of transitional types exist. Several attempts have been made to express the serial magmatic character by numerical values (e.g. NIGGLI's « isofaly », TROEGER's differentiation cube, RITTMANN's si-an-diagram etc.). In the following shall be shown how such a numerical value can be obtained directly from the weight percentages of the chemical analyses.

Plotting the value « An » against SiO_2 % one obtains a diagram in which the alkaline series appear well separated from the calc-alkaline ones. As has been shown in an earlier paper (°) $An = (Al - Alk)/(Al + Alk)$ in which $Al = 0.9\, Al_2O_3$ and $Alk = K_2O + 1.5\, Na_2O$, all in weight percentages. Figure 1 represents such a diagram in which all analyses of relatively fresh lavas of the Indonesian Volcanoes, reported in the Catalogue of Volcanoes, have been plotted. The average trend of the plottings of fresh lavas of any single volcano can be represented ap-

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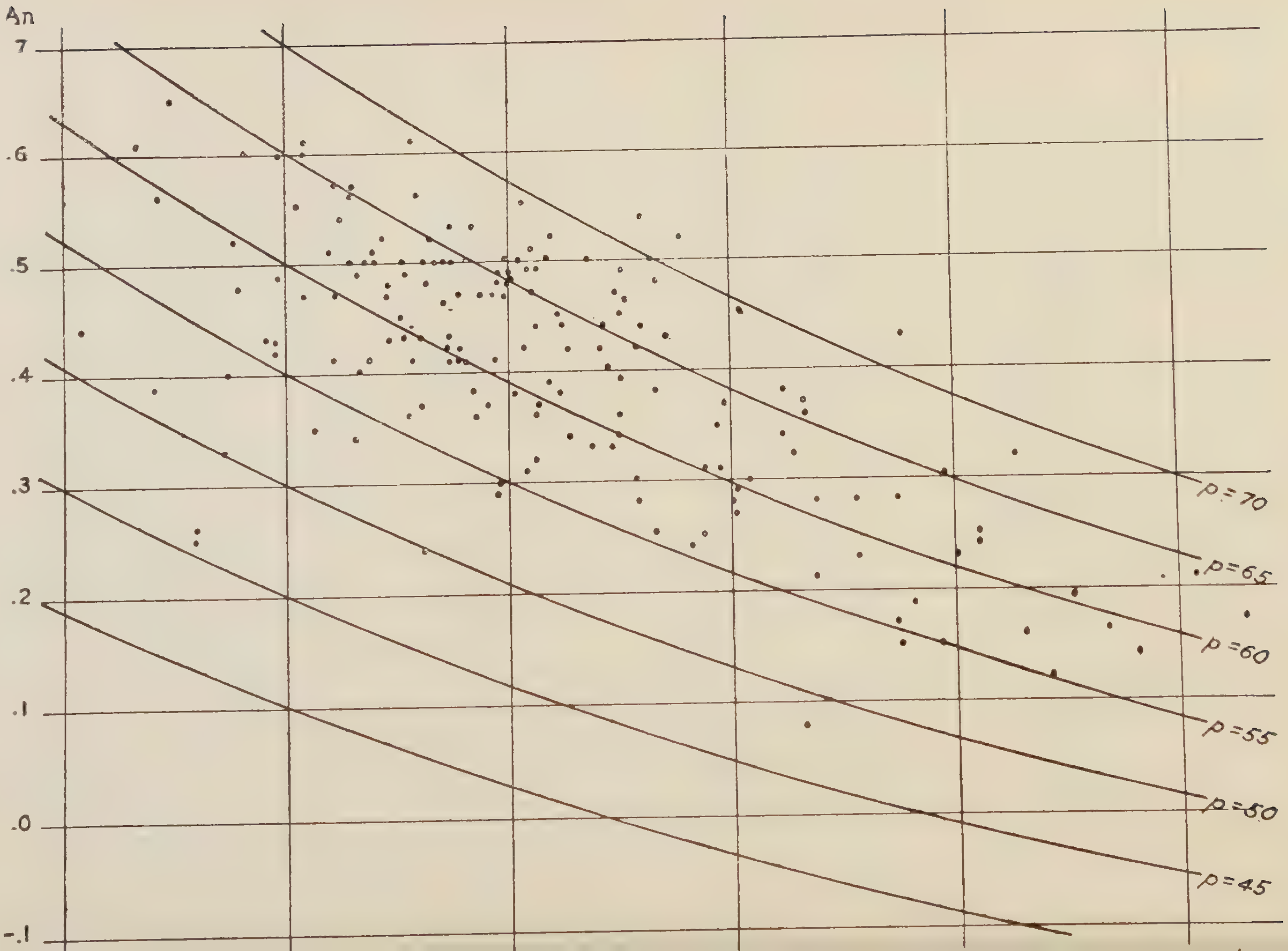
(°) A. RITTMANN - *Nomenclature of volcanic rocks*. Bull. Volcanologique, Série II, Tome XII, Napoli 1952.


An
7
.6
.5
.4
.3
.2
.1
.0
-.1
p=70
p=65
p=60
p=55
p=50
p=45

proximately by hyperboles, $xy = p$, in which $x = SiO_2\ \%$ and $y = (An + 0.70)$. The parameter p can be calculated for each analysis according to the above definition of x and y. It results then empirically that all types of recent lavas of a given volcano show approximately the same p-values, even if they are highly differentiated.

The following table I gives the $SiO_2\ \%$ and the values of $k = K_2O/Alk$, $An = (Al - Alk)/(Al + Alk)$ and $p = SiO_2\,(An + 0.70)$ for all analyses of relatively fresh rocks of the Indonesian Volcanoes published in the Catalogue of Volcanoes.

TABLE I

Volcano	*rock*	SiO_2	*k*	*An*	*p*	*new name of the rock (chem.)*
Barren Isl.	I	49.1	.17	.60	63.9	basalt (olivine-free)
(6,0)	II	53.0	.10	.56	66.8	andesite
	III	53.6	.10	.46	62.2	andesite
	IV	53.7	.15	.42	60.2	andesite
Sibajak	—	56.4	.32	.42	62.0	labrador-trachyandesite
(6,1-7)						
Sorik Marapi	491	57.9	.27	.42	64.8	bandaite (to dacite)
(6,1-12)	493	58.3	.32	.48	68.8	bandaite (to rhyodacite)
Talakmau	179	57.2	.22	.40	62.9	dacite (to andesite)
(6,1-13)	197	59.7	.23	.35	62.7	dacite
	160	61.4	.24	.32	62.6	dacite
Marapi	II	53.7	.22	.41	59.6	pigeonite-andesite
(6,1-14)	285	55.2	.29	.38	59.6	trachyandesite
	332	55.5	.39	.31	56.0	trachyandesite
	388	59.2	.28	.24	55.7	rhyodacite (to trachyandesite)
	I	61.9	.32	.21	56.3	rhyodacite
Tandikat	519	59.9	.26	.37	64.1	dacite
(6,1-15)	521	61.2	.29	.38	66.0	rhyodacite
	522	61.7	.30	.37	66.1	rhyodacite
	505	64.2	.29	.35	67.4	rhyodacite
Dempo	I	61.2	.35	.34	63.6	rhyodacite
(6,1-23)						

(Table I continues)

Volcano		*rock*	SiO_2	*k*	*An*	*p*	*new name of the rock (chem.)*
Krakatau	I.	2298	70.4	.34	.21	64.0	« rhyodacites », probably auto-
(6,2)		2283	71.5	.31	.17	62.2	pneumatolyzed andesites! (Tridym.)
	II.	2081	50.2	.22	.55	62.9	pigeonite-andesite
		2289	53.6	.19	.48	63.3	pigeonite andesite
	IIIA.	2264	65.5	.32	.25	62.9	rhyodacite
		2085	65.6	.25	.24	61.7	rhyodacite
		929	69.1	.25	.14	58.0	rhyodacite
		8231	51.0	.24	.51	61.7	labradorite-andesite (ash)
	IIIB.	8233	65.1	.34	.23	60.5	rhyodacite (pumice)
		2317	67.6	.32	.19	60.2	rhyodacite »
		2339	63.8	.27	.28	62.4	rhyodacite »
		14	68.4	.19	.16	58.9	light dacite (bomb)
	IV.	2088	51.8	.19	.50	62.1	labradorite-andesite (ash, altered)
		2958	52.9	.13	.41	58.7	pigeonite-andesite (ash)
		A	55.0	.29	.39	60.0	trachyandesite (ash)
		4047	54.8	.11	.41	60.8	pigeonite-andesite
Tangkuban		2478	56.3	.43	.38	60.8	trachyandesite
Prahu.		2477	56.4	.35	.34	58.6	trachyandesite
(6,3-9)		2476	57.4	.38	.33	59.1	trachyandesite
		2474	57.9	.40	.30	57.9	trachyandesite
Papandajan		4109	55.6	.17	.51	67.4	bandaite (poor in quartz)
(6,3-10)		2105	56.0	.26	.52	68.4	bandaite » » »
Guntur		2447	52.0	.16	.51	63.0	labradorite-andesite
(6,3-13)		4146	61.8	.21	.36	65.5	dacite (to rhyodacite)
Galunggung		4150	50.4	.07	.61	66.0	labradorite-andesite
(6,3-14)		4148	55.7	.10	.44	63.6	pigeonite-andesite
		4154	56.1	.11	.45	64.6	pigeonite-andesite
		260	56.2	.10	.44	64.1	dacite (to pigeonite-andesite)
Tjerimai		4237	53.9	.17	.47	63.0	labradorite-andesite
(6,3-17)		4233	54.4	.19	.47	63.5	labradorite-andesite
		4229	58.3	.24	.38	63.0	dacite (to trachyandesite)
		4238	55.4	.20	.42	62.0	pigeonite-andesite

(Table I continues)

Volcano	*rock*	*SiO_2*	*k*	*An*	*p*	*new name of the rock (chem.)*
Slamet (6,3-18)	3956	54.2	.25	.38	58.6	trachyandesite
	111	55.9	.24	.39	60.9	trachyandesite (to andesite)
	2834	49.0	.23	.48	57.9	labradorite-andesite (±olivine)
	2754	49.5	.22	.43	56.0	olivine-andesite
	2814	49.7	.23	.43	56.2	olivine-(trachy)andesite
	2885	50.5	.18	.47	59.1	labradorite-andesite
	2634	52.8	.20	.43	59.7	pigeonite-andesite
	2635	52.3	.19	.47	61.1	labradorite-andesite
	2638	51.7	.22	.40	57.0	pigeonite-andesite
	2636	52.3	.16	.48	61.7	labradorite-andesite
	3877	54.0	.20	.41	61.6	pigeonite-andesite
Diëng (6,3-20)	2629	51.2	.22	.47	60.0	labradorite-andesite
	4090	53.1	.28	.43	60.0	trachyandesite
	4100	55.6	.27	.36	59.0	trachyandesite
	4104	55.8	.34	.37	59.8	trachyandesite
	4087	57.5	.41	.36	61.0	trachyandesite
	4092	60.5	.34	.30	60.5	rhyodacite
	4093	62.9	.41	.23	58.5	quartz-latite
Sumbing (6,3-22)	4265	59.9	.31	.32	60.1	rhyodacite (poor in quartz)
	4263	60.4	.24	.35	63.4	dacite (to rhyodacite)
	4262	60.9	.23	.30	60.9	dacite
	4259	62.1	.27	.32	63.3	rhyodacite
Ungaran (6,3-23)	2042	45.0	.36	.50	54.0	olivine-trachybasalt
	600	51.5	.37	.34	53.6	olivine-trachyandesite
	601	50.7	.35	.35	53.2	olivine-trachyandesite
	2044	54.8	.36	.29	54.2	trachyandesite
	603	51.1	.33	.41	56.7	labradorite-trachyandesite
	2040	53.1	.34	.37	51.1	trachyandesite
	2043	54.3	.36	.36	52.1	trachyandesite
	2046	57.4	.34	.33	53.4	trachyandesite
Merbabu (6,3-24)	167	49.9	.31	.49	59.3	olivine-trachyandesite
	753	51.9	.25	41	57.5	trachyandesite

(Table I continues)

Volcano	*rock*	SiO_2	*k*	*An*	*p*	*new name of the rock (chem.)*
Merapi	4170	51.9	.30	.50	62.2	labradorite-(trachy)andesite
(6,3-25)	52	52.2	.34	.52	63.6	labradorite-trachyandesite
	4077	52.6	.29	.50	63.1	labradorite-andesite
	4172	52.7	.31	.49	62.7	trachyandesite
	3961	53.1	.34	.50	63.6	labradorite-trachyandesite
	4173	53.3	.27	.52	65.0	labradorite-andesite
	4171	53.7	.26	.50	64.5	labradorite-andesite
	85	54.2	.34	.53	66.7	labradorite-trachyandesite
	94	55.3	.34	.50	66.3	labradorite-trachyandesite
	3960	55.5	.32	.49	66.0	labradorite-trachyandesite
	70	55.6	.34	.49	66.1	labradorite-trachyandesite
	97	51.5	.37	.50	61.8	olivine-trachyandesite
	3190	54.8	.32	.49	65.2	labradorite-trachyandesite
	3191	54.8	.35	.47	64.1	labradorite-trachyandesite
	3189	55.6	.35	.47	65.0	labradorite-trachyandesite
	3193	55.0	.35	.47	64.4	labradorite-trachyandesite
	4031	54.7	.24	.47	64.0	labradorite-andesite
	4030	54.9	.30	.48	64.8	labradorite-trachyandesite
	626	54.6	.35	.47	63.9	labradorite-trachyandesite
	473	55.0	.34	.48	65.0	labradorite-trachyandesite
Kelud	1012	55.4	.17	.55	69.1	bandaite
(6,3-28)	1385	52.6	.19	.45	60.5	andesite (to basalt)
	1398	53.6	.16	.50	64.4	labradorite-andesite
	1391	57.0	.16	.42	63.9	dacite (to bandaite)
	1397	58.0	.22	.44	66.1	dacitic bandaite
	16	57.6	.15	.49	68.6	bandaite
Semeru	4574	46.7	.15	.61	61.2	olivine-labradorite-andesite
(6,3-30)	4535	49.9	.16	.60	64.8	labradorite-andesite
	I	55.8	.25	.50	67.0	dacitic labradorite-andesite
	II	57.5	.23	.34	59.8	dacite
	2656	57.5	.16	.39	62.7	dacite
	4576	58.5	.19	.43	66.0	dacite
	4532	57.1	.20	.44	65.1	dacite (to bandaite)
	4533	57.5	.18	.47	67.3	bandaite
	4534	57.5	.21	.45	66.2	dacite (to bandaite)
Bromo	IIIg	59.1	.46	.26	56.7	dark quartz-latite
(6,3-31)	IIIi	55.4	.50	.49	66.0	dark rhyodacite (remolten?)
	2479	54.3	.45	.47	63.5	labradorite-trachyandesite (ash)
	2725	56.1	.44	.39	61.2	labradorite-trachyandesite (ash)
	2643	55.8	.25	.34	59.1	trachyandesite

(Table I continues)

Volcano	*rock*	SiO_2	*k*	*An*	*p*	*new name of the rock (chem.)*
Lamonggan (6,3-32)	4045	47.5	.15	.65	63.2	labradorite-andesite (+olivine)
Raung (6,3-34)	21	52.9	.35	.61	69.3	labradorite-andesite
	26	55.0	.36	.50	66.0	labradorite-trachyandesite
	4	58.9	.34	.52	71.9	bandaite (to rhyodacite)
	5	58.2	.32	.50	69.9	bandaite
	59	56.8	.30	.50	68.2	bandaite (ash)
	63	55.0	.34	.49	66.4	labradorite-trachyandesite
	46	52.9	.35	.54	65.6	labradorite-trachyandesite
	30	52.8	.26	.36	56.0	trachyandesite (±olivine)
	34	52.4	.34	.43	59.2	labradorite-trachyandesite
Batur (6,4-1)	I	51.1	.21	.57	65.0	labradorite-andesite
	II	51.5	.17	.57	65.4	labradorite-andesite
	III	51.2	.22	.54	63.7	labradorite-andesite
	IV	51.5	.20	.56	64.8	labradorite-andesite (ash)
	V	50.5	.12	.60	65.5	labradorite-andesite
	VI	53.7	.22	.53	66.0	labradorite-andesite
	VII	64.7	.27	.15	55.0	rhyodacite (pumice)
	VIII	62.8	.25	.28	61.5	rhyodacite (pumice inclusion)
Paluweh (6,4-15)	2241	48.6	.16	.33	50.1	andesine-basalt
	2217	54.9	.22	.30	54.9	trachyandesite
	2233	58.3	.25	.25	55.4	rhyodacite (to trachyandesite)
	2228	59.5	.29	.31	60.0	trachyandesite
	2221	60.1	.34	.28	59.0	rhyodacite
	2253	59.4	.28	.25	56.4	rhyodacite (to trachyandesite)
	2261	57.8	.32	.28	56.6	trachyandesite (to rhyodacite)
	2192	59.1	.28	.24	55.6	trachyandesite (to rhyodacite)
Ili Boleng (6,4-22)	43	55.6	.25	.36	59.0	trachyandesite
	41x	62.0	.31	.28	60.8	rhyodacite
Lewotolo (6,4-23)	61	48.9	.34	.52	59.6	olivine-trachybasalt
	61x	47.1	.16	.61	61.6	olivine-basalt
	51	60.1	.43	.27	58.4	quartz-latite
	55x	60.2	.42	.29	59.6	quartz-latite
	53	55.6	.37	.32	56.7	trachyandesite
	57	56.9	.42	.33	58.6	trachyandesite

(Table I continues)

Volcano	*rock*	*SiO_2*	*k*	*An*	*p*	*new name of the rock (chem.)*
Batu Tara	1	47.1	.55	.39	51.3	leucite-basanite
(6,4-26)	14x	48.0	.63	.26	46.1	leucite-basanite
	17x	48.0	.67	.25	45.5	leucite-basanite
	2	48.7	.56	.40	53.5	dark latite (leucite bearing)
	15	45.4	.59	.44	51.7	leucite-basanite
	16	53.1	.50	.24	50.0	latite (leucite bearing)
Una-Una	423	61.7	.27	.08	48.2	soda-trachyte
(6,6-1)						
Lokon Empung	623	49.8	.10	.42	55.7	andesine-basalt
(6,6-10)	614	51.6	.14	.49	61.4	labradorite-andesite
	617	54.5	.11	.37	58.4	andesite
	655	66.7	.34	.16	57.4	quartz-latite
	620	67.2	.22	.12	55.1	rhyodacite
Ruang	I	57.7	.19	.46	67.0	bandaite (to dacite)
(6,7-1)						
Awu	I	47.1	.23	.56	59.5	basalt
(6,7-4)	II	53.9	.33	.42	60.3	labradorite-trachyandesite
Dukono	241	53.7	.25	.43	60.6	labradorite-andesite to basalt
(6,8-1)	1735	52.9	.19	.50	63.4	labradorite-andesite
	1734	59.7	.27	.31	60.3	rhyodacite
	239	63.7	.43	.17	55.5	quartz-latite
	232	63.8	.36	.15	54.2	quartz-latite
	3991	64.1	.32	.19	57.1	rhyodacite

From table I follows that the p-values are nearly constant in many cases as e.g. for the volcanoes Talakmau, Tandikat, Tjerimai, Diëng, Merapi, Lewotolo etc. In other cases single analyses give, however, outstanding p-values. The reasons for such deviations can be very different ones:

1. Analyses of inferior quality. Analytical errors of any kind may occur, but the most common ones are characterized by too high values for Al_2O_3 and too low ones for the alkalies. In these

cases the p-values appear naturally too high. In table I only a few inferior analyses have been omitted as e.g. the uncomplete analysis 2431 of Tangkuban Prahu.

2. Analyses of weathered rocks. By weathering alkalies are leached out, and also some lime may be lost. This causes a passive enrichment in allumina and silica and, consequently, a rapid increasing of the p-value. The analysis 2475 of Tangkuban Prahu regards surely a strongly weathered rock for which the value $ca'' = CaO - 0.6\,(Al - Alk)$ is negative (-5.84), indicating that the molecular sum of alkalies and lime is smaller than allumina. The value « An » looses its sense, because the available lime is insufficient to form the corresponding anorthite molecules. The p-value, calculated on the base of this senseless « An », becomes much too high (69.3 instead of 59.1).

3. Analyses of pneumatolyzed rocks. The effect of fumarolic action on volcanic rocks varies with the temperature and the composition of the gases. At high temperature alkalies may be added, producing a decrease of the p-value. The same may happen also in the case of a pneumatolytic differentiation preceeding a Plinian eruption, especially in the highest levels of the magma column. On the contrary, at lower temperatures alkalies are leached out and the p-value increases.

4. Analyses of ashes give sometimes a wrong idea about the chemical composition of the magma. In fact ashes are often partially constituted by crushed wall rocks of the volcanic vent and, even if they are purely magmatic, they undergo easily any kind of alteration.

5. Analyses of « basic inclusions » give mostly unsuitable p-values because they do not represent the magma itself but accumulations of segregated crystals, metamorphosed roof-rocks etc. The analyses 2243, 2219, 2206 and 2236 of Paluweh have therefore been excluded from table I.

6. Analyses of older volcanic rocks belonging to an earlier stage of the magmatic evolution. It is a matter of fact that the magmas of many volcanoes undergo an evolution besides the eventual differentiation. Extreme examples are given by Somma-Vesuvius (RITTMANN 1933) and other volcanoes of the potassic series. But also volcanoes of other series show temporal

variations of their serial character. Thus the calc-alkaline character of the Krakatau-magma is weakening with time as shown by the following average values for p:

Rakata (II)	p = 63.1
Perbuwatan and Danan (IIIA)	60.8
Eruption of 1883 (IIIB)	60.5
Anak Krakatau (IV)	59.8

Similar facts are shown by the Diëng-magma which has decreasing p-values with time from about 61 to 58.5, and by the magmas of Raung, Dukono etc.

The petrographical indications reproduced in the Catalogue of Volcanoes of Indonesia are not sufficient to etablish the reasons for outstanding p-values in each single case. Only a few inferior analyses and some analyses of altered rocks and basic inclusions have been excluded from table I which, certainly, contains still a number of doubtful analyses, marked by (?) after the chemical name of the rock. Notwithstanding this source of errors the average p-values for each volcano furnish in most cases suitable figures to indicate the serial magmatic character of it.

In table II all volcanoes, for which chemical data are known, are arranged according to decreasing average p-values. The p-value of 55 may be taken as limit between calc-alkaline series and the alkaline ones. Among these latter the k-value of .40 separates the potassic from the normal alkaline series. The following scheme may be used as subdivision:

average p-value	*character of the series or single rocks*	
higher than 70	extreme calc-alkaline	= « pacific series »
65 to 70	strong » »	
60 to 65	medium » »	
55 to 60	weak » »	
50 to 55	weak alkaline	k smaller than .40:
45 to 50	medium »	= « atlantic series »
40 to 45	strong »	k greater than .40: (=potassic)
lower than 40	extreme »	= « mediterranean series »

TABLE II

Serial magmatic character of the Indonesian Volcanoes

Nr and name of volcano		*p-value*	*k-value*	*SiO_2%*	*remarks*
6,3-10	Papandajan	67.9	.21	55.8	
6,7- 1	Ruang	67.0	.19	57.7	only 1 analysis
6,1-12	Sorik Marapi	66.8	.29	58.1	
6,1-15	Tandikat	65.9	.28	61.7	
6,3-34	Raung	65.8	.33	55.0	older lavas p=68.2
6,3-28	Kelud	65.5	.17	55.7	
6,3-30	Semeru	65.3	.19	55.3	
6,3-14	Galunggung	64.7	.10	54.6	
6,3-25	Merapi	64.4	.32	54.5	
6,4- 1	Batur	64.3	.21	54.6	
6,3-13	Guntur	64.3	.18	56.9	
6,1-23	Dempo	63.6	.35	61.2	only 1 analysis
6,0-—	Barren Island	63.3	.13	52.4	
6,3-32	Lamonggan	63.2	.15	47.5	only 1 analysis
6,3-17	Tjerimai	62.9	.20	55.5	
6,1-13	Talakmau	62.7	.23	59.4	
6,3-22	Sumbing	61.9	.26	60.8	
6,2-—	Krakatau	60.9	.24	60.2	average II to IV
6,3-31	Bromo	60.1	.40	56.3	
6,4-22	Ili Boleng	59.9	.28	58.8	
6,7- 4	Awu	59.9	.28	50.5	
6,3-20	Diëng	59.8	.32	56.7	recent p=58.5
6,3- 9	Tangkuban Prahu	59.1	.39	57.0	
6,4-23	Lewotolo	59.1	.37	54.8	
6,3-18	Slamet	59.0	.21	52.0	
6,8- 1	Dukono	58.5	.30	59.6	
6,3-24	Merbabu	58.4	.28	50.9	
6,1-14	Marapi	57.4	.30	57.1	
6,6-10	Lokon Empung	56.7	.19	59.5	
6,4-15	Paluweh	56.0	.27	57.2	
6,3-23	Ungaran	53.5	.35	52.2	
6,4-26	Batu Tara	49.7	.58	48.4	
6,6- 1	Una-Una	48.2	.27	61.7	only 1 analysis

From table II results that out of the 33 discussed Indonesian Volcanoes 30 pour out calc-alkaline magmas of various types, while only three belong to the alkaline series as shown in table III:

TABLE III

Frequency of the serial magmatic characters of Indonesian Volcanoes

magmatic series		*number of volcanoes*	*in %*
strong calc-alkaline	= pacific	7	21%
medium calc-alkaline		12	37%
weak calc-alkaline		11	33%
weak alkaline	= atlantic	1	3%
medium alkaline		1	3%
medium potassic	= mediterranean	1	3%

Considering now the tectonical position of these volcanoes one states immediately that the medium alkaline Una-Una lies outside of the orogenic belt in the already more or less cratogenized hinterland, while the potassic Batu Tara is situated in a subsiding part of the hinterland. Also the weak alkaline Ungaran lies on the backfront of the orogenic belt towards the hinterland.

On the contrary, all calc-alkaline volcanoes are situated within the active orogenic belt itself, according to the well known rule. But, there is more than that: nearly all medium calc-alkaline volcanoes lie in a relatively narrow zone parallel to the orogenetic axis, while all strong calc-alkaline volcanoes are situated southwards of this zone i.e. towards the foreland. On the contrary, all weak calc-alkaline volcanoes lie northward of this zone, i.e. towards the hinterland. This may be expressed in other words in the following rule:

In any given cross-section through the Indonesian orogenic belt the calc-alkaline character of the magmas of the active volcanoes decreases regularly in the direction from the foredeep to the hinterland, becoming alkaline in the hinterland itself.

This rule has to be integrated by the statement that:

At single volcanoes the calc-alkaline character decreases with time. This latter statement confirms clearly the migration of the axis of the orogen towards the foredeep already observed by geologists.

There are but very few exceptions to the above rule, that have to be discussed briefly. Tjerimai shows a p-value of 62.9

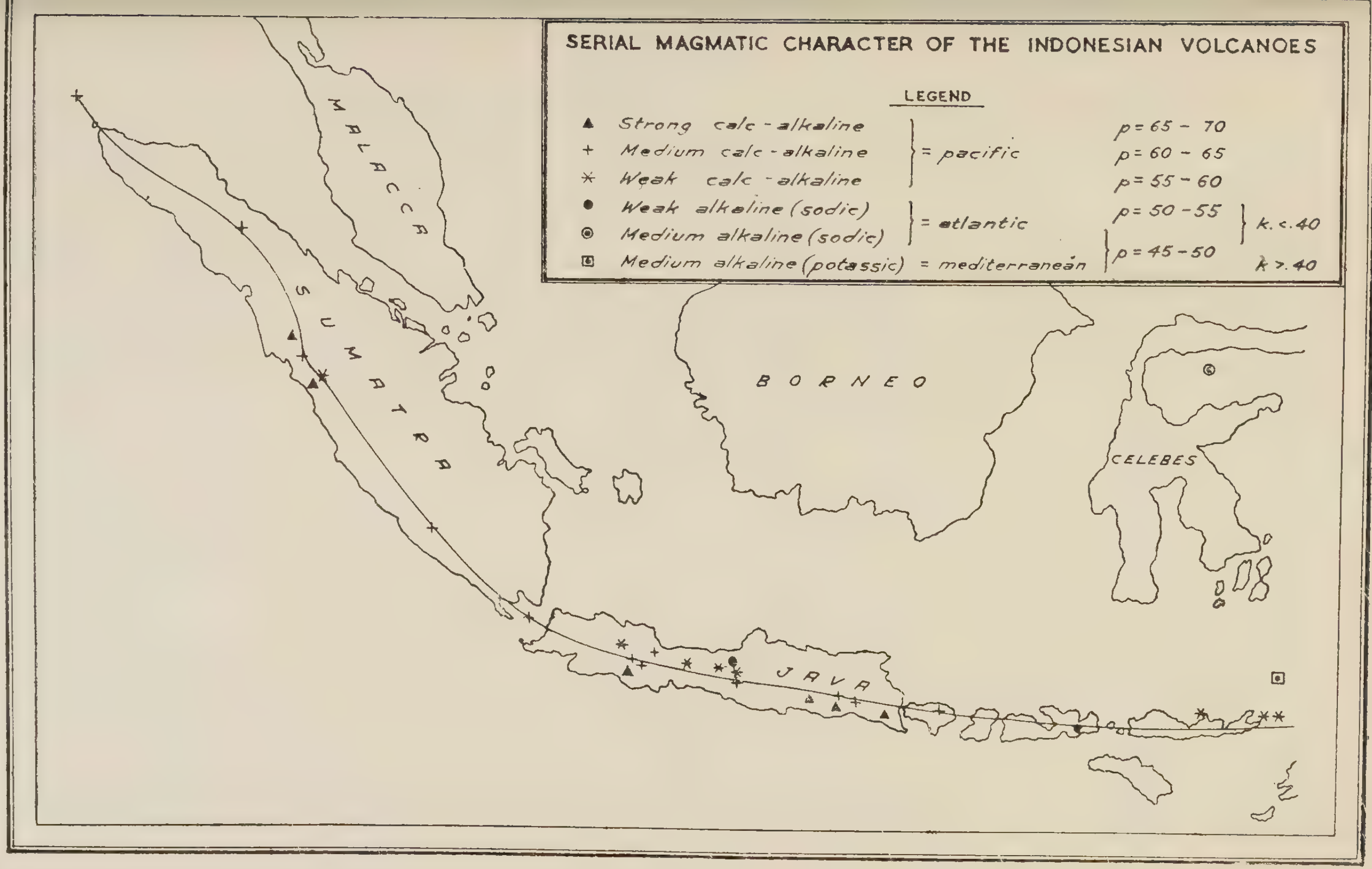

SERIAL MAGMATIC CHARACTER OF THE INDONESIAN VOLCANOES
LEGEND
▲ Strong calc-alkaline
+ Medium calc-alkaline
✳ Weak calc-alkaline
● Weak alkaline (sodic)
◎ Medium alkaline (sodic)
⊡ Medium alkaline (potassic)
= pacific
= atlantic
= mediterranean
p = 65 - 70
p = 60 - 65
p = 55 - 60
p = 50 - 55
p = 45 - 50
k. < .40
k > .40
MALACCA
SUMATRA
BORNEO
CELEBES
JAVA

Fig. 2

(average of 4 analyses) while, according to its tectonical position, one should expect a lower value of about 58. Also Sorik-Marapi seems to have an exceptionally high p-value, namely 66.8 (average of 2 analyses with p = 64.8 and 68.8), while Talakmau shows only p = 62.7, notwithstanding its nearly analogous position. It could be that unfresh rocks had been analysed or also that the analyses are inferior, but it is also possible that one has to deal with really abnormal p-values. In fact, Sorik-Marapi lies on an inflection of the tectonic strike, and also Tjerimai may be situated on a paraphoric fracture. If so, the abnormal p-values could be explained by the intrusion of high-orogenic magma in fractures across the orogenic belt. In the actual state of our knowledge it is not possible to reach a sure conclusion. Further analyses of fresh lavas are needed.

These few statements may be sufficient to demonstrate the importance of good chemical analyses of fresh volcanic rocks in order to establish the very interesting relations existing between structural Geology and Magmatology. Once established more accurately, these relations will throw a new light on the origin of magmas and on the mechanism of their eruptions, contributing thus greately to the development of Volcanology and theoretical Geology.

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On the old and the new systems of nomenclature of Volcanic Rocks.

Introduction

The uniformity of nomenclature has been always considered as an essential basis of all petrographic researches, and several systems of nomenclature have been attempted. These systems, however, hardly reached the full requirement of both petrographic work and the great diversity of rock types introduced by the various workers. The difficulty of achievement of a uniform scheme of nomenclature that can be in most cases applied can be attributed to two major factors which are discussed below.

Many rock names bear no mineralogical meaning but are purely geographical. So it happens often that mineralogically and chemically very similar or even identical rocks are named differently. Thus, whenever a scheme of nomenclature is attempted it will be stirred up by these local names and will consequently hinder the attainment of a uniform scheme of nomenclature. This difficulty becomes evident when volcanic rocks are concerned as they are in most cases fine grained or even glassy so that chemical analysis is the only mean for their classification and nomenclature.

Difficulties are also met with when the nomenclature is based on mineralogical characters of the rocks. In the case of volcanic rocks the quantitative mineralogical classification fails to reveal the true nature of these rocks, while on the contrary it can be said safely that it is the most suitable classification in case of sufficiently coarse grained holocrystalline rocks. The porphyric crystals, frequently seen in the volcanic rocks, cannot by any means be considered as a distinctive mineralogical feature of the rocks. This because these phenocrysts may not unlikely be arrested stages in the course of magmatic crystallization, i. e. not in equilibrium with the melt. So e. g., the presence of phenocrysts of basic plagioclases does not mean that the rocks is a basalt as is usually considered by several petrographers.

Moreover, the cryptocrystalline or glassy groundmass in a rock may probably contain quite different types of minerals optically indeterminable or occult in the groundmass. These facts have often been ignored by petrographers and were leading to ambiguous denominations. Therefore, the so called basalts by some authors are really andesites or even dacites, often with appreciable amounts of normative sanidine in the groundmass. For these reasons chemical analysis is considered to be the most suitable mean for the nomenclature of volcanic rocks.

During the Volcanological Congress held in Brussels in 1951, A. RITTMANN has proposed a new system of nomenclature, to be used in the Catalogue of Volcanoes, and Key Tables for determination of volcanic rocks. In his system of nomenclature, the author has taken into consideration the above mentioned difficulties and approaches a high degree of uniformity in his system of nomenclature.

In the present study, an attempt is made to verify to what extent do the old systems of nomenclature agree with this new system proposed by A. RITTMANN. For this, the Volcanic Rocks of Indonesia (reported in the Catalogue) have been chosen because they are great in number, chemically analysed and include a wide variation among themselves.

Petrographical Comparisons

For the purpose of comparison 183 chemical analyses for rocks from the Catalogue of Indonesian Volcanoes were calculated by the present writer into their norms according to the American System of Nomenclature (C.I.P.W.).

In table I, the new names according to the normative composition is given in column 2, together with the new names for these rocks according to the chemical system proposed by A. RITTMANN, (col. 3). In the same table the original names used by authors are given in col. 1. For convenience the latter are grouped into families and to each rock type is assigned the number of the volcano and the number of the specimen as given in the Catalogue, for reference.

From this table the disagreement between the old names and those based on the norm is striking. On the other hand the agreement between the latter names and those according to the new chemical system is conceivable. This difference is further elucidated in table II, where the difference between the frequences of the rock types in each family is given.

Before discussing in detail the discrepancies between the names according to the norm and the old names, it is to be remembered that the old names are based mainly on the mineralogical composition, i. e. the identifiable minerals. So, the term basalt has been assigned to rocks in which the essential plagioclase felspar is calcic while the relative proportion of the salic and femic constituents had not been taken into consideration. In several cases it has been found that the normative femic constituents in the rocks named as basalts in the old nomenclature do not exceed 20 % although the normative plagioclase is labradorite. To such rocks other names than basalts were given with the prefix labradorite to indicate that the plagioclase is a basic variety. The limits assigned to the femic constituents are those of the American System of nomenclature. Accordingly, as is seen in table II, out of the 54 so called basalts, 6 were only found to be true basalts and the rest are mainly andesitic rocks with labradorite as dominant felspar in most cases. Moreover, among these andesitic rocks some are found to contain normative sanidine in such amounts (about 10 % of the total felspar) that the term trachyandesite is justyfiable. In the latter rocks labradorite may also be the main felspar and rocks were accordingly called labradorite-trachyandesites.

Among the six tephritic rocks (leucite basanites) one was found to be a latite with nepheline and olivine. The appearance of nepheline in the norm instead of leucite is found to be a striking ambiguity in the C.I.P.W. method of calculation and the names deduced disagree with both the old nomenclature and that of the new chemical system. This feature deserves discussion but this will be detained until the comparison between the C.I.P.W. and the new chemical methods of nomenclature are discussed.

Finally, as to the 123 andesitic rocks, it was found that according to their norms 67 can be called really andesitic rocks (including andesites, trachyandesites, and latites), while 55 are dacitis rocks (including rhyodacites, dacites and bandaites) and 1 is a trachytic rock. The distinction between these rock types is based on the relative proportions of the salic and the femic constituents and on the relative proportions of the normative potash felspar (sanidine) and plagioclase. Many of the andesites in the old nomenclature are found to be trachyandesites with labradorite as the main felspar. The sanidine may form about 14 % of the total felspars, and it is most probably occult in the groundmass as in the case of the vitrophiric rocks 6,3 - 25 (no. 85 - 473).

Considering the new chemical system of nomenclature, its agreement with that according to the norm composition is much greater than that of the old nomenclature. This can be seen when the rock families are compared in both systems, table II. In detail the correspondence is still distinct although deviations could be noticed when the frequency of the rock types are compared as is shown in table III. As is seen in both tables the rocks named basalts are equal in their frequency in both methods of nomenclatures. The other variations are discussed below.

The most striking difference between the nomenclature according to the new chemical system, as well as that according to the old one, and the C. I. P. W. method of nomenclature is found among the tephritic rocks. This is shown by the appearance of modal leucite instead of normative nepheline. WASHINGTON and others have found that in certain tephritic rocks leucite and not nepheline is the first to be formed, or dominates over the latter when they are found together. Thus, it seems that ordinary norm calculation leads to ambiguous results and the calculation of the norm should be based on modal composition. For this a survey of the modal composition of tephritic rocks was made and it shows the following features:

1) In tephritic rocks it has been found that there is a definite relation between the formation of either leucite or nepheline and the molecular quotient $k = K_2O : (K_2O + Na_2O)$.

When this quotient is greater than 0.4 leucite is formed alone, and when it is smaller nepheline is formed. At nearly 0.4 both leucite and nepheline are formed together. These relations lead to the fact that provisional orthoclase should be the first to be desilicated in the norm calculations in most of the rocks dealt with in this paper.

2) A survey of the composition of the augites in tephritic rocks shows that they contain at least 5 % Tschermack molecule, and about 1/5 more (En + Hy) than the theoretical composition of diopside in the C.I.P.W. norm calculation. In other words the augite should be calculated on the basis of the following composition: $Wo_{41}\ Ts_4\ En_{38}\ Hy_{17}$. By converting the percentages of these components into molecular proportions it is found that the molecular of total MgO (normative En) and the rest of FeO, as normative Hy, should be about in the ratio 7:3. As the magnetite in tephritic rocks does not exceed modally 5 % while it is much higher in the norm, part of the normative magnetite should be converted to hypersthene in order to have the ratio 7:3, according to the following equation: $1\,Mt + 3\,Q = 3\,Hy$.

3) The introduction of Tschermack molecule to the augite will automatically lower the anorthite content in the norm.

4) Finally, in tephritic rocks the sanidine contains always about 30-35 % albite.

By taking into account these facts the modal compositions of the tephritic rocks were recalculated and the results are given in table IV together with their norms according to C.I.P.W. for comparison. As is seen from the table, there is a close agreement between the names arrived at by the modal calculation and those according to the new chemical system. This indicates that the new chemical system of nomenclature may be considered as the best approximation to the actual characters of the rocks.

In relation to the difference between the modal composition and norm calculation are the discrepancies found with regard to the rock 6.4 - 23 (no. 61) which is called trachyandesite according to C.I.P.W. method and trachybasalt (with olivine) according to the new chemical system of nomenclature. By calculating the norm of this rock (C.I.P.W.) it is found that magnetite is about 9 %, which seems to indicate that this rock suffered oxidation. This can be ascertained from the composition of the normative augite, being Wo_{30} En_{67} Hy_{3}, which is impossible in such rocks. Accordingly, part of the normative magnetite should be transferred to pyroxene. Free silica will be used for the Hy and consequently olivine will appear in the norm. But as some of the anorthite content will enter the pyroxene as Tschermack molecule (about 10 % Wo) an equal amount of silica will be released to combine with part of the olivine to form pyroxene. Accordingly the femic constituents will be increased to about 42 per cent and the rock can be called trachybasalt (with olivine), thus showing full agreement with the new chemical system.

Discrepancies are also found among the rocks 6,3 - 18 (no. 2754 and 2814) being specified by the presence of labradorite as the essential felspar according to the norm. This is due to the fact that in the new chemical system of calculation the constructed diagrams are based on the volume percentage of albite and anorthite, as in the modal composition of the plagioclase felspars while in the norm the anorthite content of the plagioclase is expressed in weight percentages and thus always higher than in the former system. Moreover, in the norm calculation the Tschermack molecule is not considered in calculating the normative pyroxene and hence the anorthite content becomes higher than in the new system.

On the other hand, the anorthite content appears lower in the normative plagioclase than in the modal one if the felspar is altered, as in the rock 6,2 (No. 2083). This rock has been called a dacite by the new chemical method respective to rhyodacite according to the C.I.P.W. method of calculation. In this rock normative corundum appears which consequently lowers the anorthite content. Had the rock been fresh, the anorthite content would have been increased and the term dacite could be assigned to this rock.

The rest of the discrepancies found in the nomenclatures by both methods regards transitional cases and seems to be due to some flexibility in the boundary lines between the groups in the diagrams constructed by A. RITTMANN in his system.

Conclusion

The nomenclature of volcanic rocks on the basis of identifiable minerals is shown in the above comparisons to be in many cases in contradiction to the actual character of the rocks under consideration. Most of the so called basalts of the Indonesian Volcanoes are for example in reality andesitic or even dacitic rocks. Thus the basicity of the plagioclase felspar phenocrysts should not be considered as an important character for a basaltic rock, but the relative proportions of the femic and salic constituents are to be considered. Applying these facts in the nomenclature based on the C.I.P.W. norm it is found that a good agreement exists between the names arrived at by this method and the new chemical method proposed by A. RITTMANN.

Reverting now to the main problem, as to the importance and wide application of the new chemical system of nomenclature, it is obvious from the detailed comparisons between it and the C.I.P.W. method that the latter shows in many cases serious defects which the new system overcomes. Thus, although it has been considered that the C.I.P.W. method of calculation is the best for representation of the chemical analyses of rocks in terms of hypothetical mineral associations, the norm is found in many cases to be quite different from what actually occurs in nature. This is especially conceivable when the norm for undersaturated rocks is calculated or for rocks that had suffered alteration by secondary processes. These discrepancies as well as others disappear when the chemical analyses are calculated on the basis of the new chemical method, by which a good approximation to the modal composition is achieved.

TABLE I. - Comparison between the old nomenclature and that according to the norm and the new chemical system.

Old names	Names according to the norm	Names according to the new chemical system
a) *Basalts:*		
6,0 (I) Olivine free basalt	Basalt	Basalt
6,2 (II) (2081) Basalt	Pigeonite andesite (near basalt)	Pigeonite-andesite
(2289) »	» »	» »
(IIIA) (8231) Basaltic ash	Pigeonite labradorite andesite	Pigeonite-labradorite-andesite
(IV) (2088) » »	» » » (-basalt)	» » »
(2958) » »	» andesite	» andesite
6,3-13 (906) Labradorite basalt	Labradorite andesite	Labradorite-andesite (unfresh)
(2447) » »	» »	Pigeonite-labradorite-andesite
6,3-14 (4150) » »	Pigeonite labradorite andesite	» » »
6,3-18 (2834) Basalt	Olivine labradorite andesite	Olivine-labradorite-andesite
(2754) »	» » »	Olivine-andesite
(2814) »	Labradorite (trachy)andesite	Olivine-(trachy)andesite
(2885) »	Pigeonite labradorite andesite	Pigeonite-labradorite-andesite
	Labradorite andesite	Labradorite-andesite

		Augite olivine basalt	Olivine trachybasalt	Olivine-trachybasalt
	(600)	» » andesite basalt	Olivine trachyandesite	Olivine-trachyandesite
	(601)	» » » »	» »	» »
	(2044)	» » » »	Trachyandesite	Trachyandesite
	(2040)	» » » »	»	»
6,3-24	(167)	Augite olivine basalt	Olivine labradorite trachyandesite	Olivine-labradorite-trachyandesite
6,3-25	(4170)	» » »	Labradorite trachyandesite	Labradorite-trachyandesite
	(52)	» » »	» »	» »
	(4077)	» » »	» »	» andesite
	(3961)	» » »	» »	» trachyandesite
	(97)	» » »	» »	» »
6,3-30	(4574)	» » »	Olivine labradorite andesite	Olivine-labradorite-andesite
	(4535)	» » »	Pigeonite labradorite andesite	Pigeonite-labradorite-andesite
6,3-31	(IIIi)	Glassy shoshonite	Labradorite trachyandesite	Labradorite-rhyodacite (abnormal)
	(2479)	Basaltic ash	» »	Labradorite-trachyandesite
	(2725)	» »	Trachyandesite (to Q-latite)	» »
	(2643)	Olivine hypersthene basalt	»	Trachyandesite
6,3-32	(4045)	Olivine basalt	Labradorite andesite (+olivine)	Pigeonite-labradorite-andesite (+olivine)
6,3-34	(21)	Augite hornblende basalt	Pigeonite labradorite andesite	Pigeonite-labradorite-andesite
	(26)	» » »	Labradorite trachyandesite	Labradorite-trachyandesite
	(59)	Basalt	Bandaite	Bandaite
	(63)	»	Labradorite trachyandesite (tc rhyodacite)	Labradorite-trachyandesite (to rhyodacite)
	(46)	»	Labradorite trachyandesite	Labradorite-trachyandesite
	(30)	»	Trachyandesite	Trachyandesite
	(34)	»	Labradorite trachyandesite	Labradorite-trachyandesite

(cont. table I)

Old names	Names according to the norm	Names according to the new chemical system
6,4-1 (I) Basalt, lava 1926	Pigeonite labradorite andesite	Pigeonite-labradorite-andesite
(II) » » »	» » »	» » »
(III) » (lapilli)	» » »	» » »
(IV) » (ash)	» » »	» » »
(V) Hypersthene basalt (lava 1905)	» » »	» » »
(VI) Basalt (+olivine), lava 1889	» » »	» » »
6,4-15 (2241) Hornblende-augite-hypersthene-basalt	Andesine basalt	Andesine-basalt
6,4-22 (43) Olivine basalt	Trachyandesite	Trachyandesite
6,4-23 (61) » »	Labradorite trachyandesite to ⟶	Trachybasalt (+olivine)
(61′) » »	Basalt (+olivine)	Basalt (+olivine)
(53) Trachybasalt	Trachyandesite	Trachyandesite
6,4-26 (1) Leucite basanite	Basanite (nepheline + leucite)	Leucite-basanite
(14′) » »	» (» »)	» » (tephrite)
(17′) » »	» (» »)	» »
(2) » »	Olivine trachyandesite (+nepheline)	Dark latite (+leucite+olivine)
6,4-26 (15) » »	Basanite (+nepheline)	Leucite-basanite
(16) Biotite leucite basanite	Latite (+nepheline+olivine)	Latite (+leucite)
6,6-10 (623) Augite olivine basalt	Andesine basalt	Andesine-basalt

6,8-1	(1734)	Olivine basalt	Labradorite andesite	Labradorite-andesite
b) *Andesites:*				
6,0	(II)	Augite andesite	Andesite	Andesite
	(III)	» »	»	»
	(IV)	» »	»	»
6,1-7		Biotite hornblende andesite	Labradorite trachyandesite	Labradorite-trachyandesite
6,1-12	(491)	Hornblende-augite-hypersthene andesite	Bandaite	Bandaite
	(493)	Augite hypersthene andesite	»	»
6,1-13	(179)	» » »	Dacite	Dacite
	(190)	» » »	»	»
	(160)	» » »	»	»
6,1-14	(II)	Augite andesite	Pigeonite andesite	Pigeonite-andesite
	(285)	» hypersthene andesite	Trachyandesite	Trachyandesite
	(332)	» » »	»	»
	(388)	» » »	Rhyodacite	Rhyodacite
	(283)	» » »	Dark rhyodacite	Dark rhyodacite
	(I)	Augite andesitic pitchstone	Rhyodacite	Rhyodacite
6,1-15	(509)	Augite hypersth. andes.	Pigeonitic andesite	Pigeonite-andesite (altered)
	(519)	» » » (+olivine)	Dacite	Dacite
	(521)	» » »	Rhyodacite	Rhyodacite
	(522)	» » »	»	»
	(505)	» » »	»	»

(cont. table I)

Old names		Names according to the norm	Names according to the new chemical system
6,1-23	(I) Pyroxene andesite	Rhyodacite	Rhyodacite
6,2 (I)	(2298) Tridymite andesite	» (to Q.latite)	» (to Q.latite)
	(2283) » »	» »	» »
(IIIA)	(2264) Andesitic scoria	»	»
	(2085) » »	»	»
	(2304) Hypersthene andesite	Dacite (to rhyodacite)	Dacite (to rhyodacite)
	(929) Augite hypersthene andesite	Rhyodacite	Rhyodacite
(IIIB)	(8233) Andesitic pumice	»	»
	(2317) » »	»	»
	(2339) » »	»	»
	(2083) » »	»	Light dacite (near rhyodacite)
	(14) » » (bomb)	» (to dacite)	» » »
(IV)	(A) Augite hypersthene andesite	Trachyandesite	Trachyandesite
	(4047) » » »	Pigeonite andesite	Pigeonite-andesite
6,3-9	(2478) Pyroxene andesite	Labradorite trachyandesite	Labradorite-trachyandesite
	(2477) » »	» »	Trachyandesite
	(2476) » »	Trachyandesite	»
	(2474) » »	»	»
6,3-10	(4109) Augite hypersthene andesite	Bandaite (to labradorite andesite)	Bandaite (to andesite)

6,3-14	(4148)	Augite labradorite andesite	Pigeonite andesite	Pigeonite-andesite
	(4154)	» hypersthene »	» »	» »
	(260)	» » »	Dacite	Dacite
6,3-17	(4237)	Aug. hypersth. andes. (+oliv.)	Pigeonite labradorite andesite	Pigeonite-labradorite-andesite
	(4233)	» » » »	» » »	» » »
	(4229)	» » » »	Dacite	Dacite
	(4238)	» » » »	Pigeonite andesite	Pigeonite-andesite
6,3-18	(3956)	» » »	Trachyandesite	Trachyandesite
	(III)	Hypersthene andesite	»	» (on the limit to andesite)
	(2634)	Andesite	Pigeonite andesite (+olivine)	Pigeonite-andesite
	(2635)	»	» labradorite andesite	» labradorite-andesite
	(2638)	»	» andesite	» andesite
	(2636)	»	» labradorite andesite	» labradorite-andesite
	(3877)	»	» andesite	» andesite
6,3-20	(4070)	Aug. hypersth. andes.	Trachyandesite	Trachyandesite
	(4100)	» » »	»	»
	(4104)	» » »	»	»
	(4087)	» » » (+hornbl.)	»	»
	(4092)	» » » (+biotite)	Rhyodacite	Rhyodacite
	(4093)	» » »	Quartz latite	Quartz-latite
6,3-22	(4265)	Augite andesite	Rhyodacite	Rhyodacite (to trachyandesite)
	(4263)	Aug. hypersth. andes. (+horn.)	Dacite	Dacite
	(4262)	» » » »	»	»
	(4259)	Hornblende andesite	Rhyodacite	Rhyodacite

(cont. table I)

Old names	Names according to the norm	Names according to the new chemical system
6,3-23 (603) Aug. hornbl. andes.	Labradorite trachyandesite	Labradorite-trachyandesite
(4041) » » » (+biotite)	» »	» »
(2043) » » » »	Trachyandesite	Trachyandesite
(2046) » » »	»	»
6,3-24 (753) Augite andesite	»	»
6,3-25 (4172) Augite olivine basalto-andesite	Labradorite trachyandesite	Labradorite-trachyandesite
(4173) Aug. hypersth. andesite	Pigeonite labradorite andesite	Pigeonite-labradorite-andesite
(4171) » » hornbl. andesite	» » »	» » »
(85) » » andes. (+hornbl.)	Labradorite trachyandesite	Labradorite-trachyandesite
(94) » » »	» »	» »
(3960) » » »	» »	» »
(70) » » »	» »	» »
(3190) » » » (vitrophyre)	» »	» »
(3191) » » » »	» »	» »
(3189) » » » »	» »	» »
(3193) » » » »	» »	» »
(4031) » » » »	Labradorite andesite	Pigeonite-labradorite-andesite (light)
(4030) » » » »	» trachyandesite	Labradorite-trachyandesite
(626) » » » »	» »	» »
(473) » » » »	» »	» »
6,3-28 (1012) Hypersthene andes. (+hornbl.)	Bandaite	Bandaite

	(1391)	» »	Dacite	Dacite
	(1397)	» »	Bandaite	Bandaite
	(16)	» »	»	»
6,3-30	(I)	Aug. hypersth. andes. (vitroph.)	Labradorite andesite	Labradorite-andesite (to dacite)
	(II)	» » » »	Dacite	Dacite
	(2656)	» » » »	»	»
	(4576)	» » » »	»	»
	(4532)	» » » »	» (to bandaite)	» (to bandaite)
	(4533)	» » » »	Bandaite	Bandaite (light)
	(4534)	» » » »	Dacite (to bandaite)	Dacite (to bandaite)
6,3-31	(IIIg)	» » »	Dark quartz latite	Dark quartz-latite
6,3-34	(4)	Hypersthene andesite	Bandaite	Bandaite (to rhyodacite)
	(5)	» »	»	»
6,4-15	(2217)	Augite hypersthene andesite	Trachyandesite	Trachyandesite
	(2233)	» » vitrophyre	Rhyodacite	Rhyodacite (to trachyandesite)
	(2228)	Hornblende hypersth. vitroph.	Trachyandesite	Trachyandesite
	(2221)	» » »	Rhyodacite	Rhyodacite
	(2253)	» » »	»	»
	(2261)	Ash, 1928	Trachyandesite	Trachyandesite
	(2292)	Pumice, 1928	»	»
6,4-22	(41′)	Pyroxene andesite	Rhyodacite	Rhyodacite
6,4-23	(51)	Hornblende pyroxene andesite (- trachyandesite)	Quartz latite	Quartz-latite
	(55′)	Hornblende pyroxene andesite (- trachyandesite)	» »	» »
	(57)	Hornblende pyrox. trachyand.	Trachyandesite	Trachyandesite

(cont. table I)

Old names	Names according to the norm	Names according to the new chemical system
6,6-10 (617) Aug. hypersth. andesite	Andesite	Andesite
(655) » » » (vitrophyre)	Quartz latite	Quartz-latite
(620) » » » »	Rhyodacite	Rhyodacite
6,7-1 (I) Hypersthene augite andesite	Bandaite	Bandaite (to dacite)
6,7-4 (II) Pyroxene andesite	Labradorite trachyandesite	Labradorite-trachyandesite
6,8-1 (241) Aug. hypersth. andesite	Labradorite andesite	Labradorite-andesite (to basalt)
(1734) » » » (vitrophyre)	Rhyodacite	Rhyodacite
(239) » » » »	Quartz latite	Quartz-latite
(232) » » » »	» »	» »
(3991) » » » »	Rhyodacite	Rhyodacite
c) *Trachytes:*		
6,6-1 (423) Hornblende biotite andesite	Soda trachyte	Soda trachyte

TABLE II. — Comparison between rock families in the old nomenclature and that according to the norm and the new chemical system, to show the frequency of the rock types in each family.

Families in old nomenclature	Basaltic rocks		Tephritic rocks		Andesitic rocks		Dacitic rocks		Trachytic rocks	
	Norm	New chem. method	Norm	New chem. method	Norm	New chem. method	Norm	New chem. method	Norm	New chem. method
1 — Basaltic rocks (54 rocks)	6	7	—	—	45	45	3	2	—	—
2 — Tephritic rocks (6 rocks)	—	—	5	4	1	2	—	—	—	—
3 — Andesitic rocks (123 rocks)	—	—	—	—	67	68	55	54	1	1

TABLE III. — Frequency of the rock types according to the norm and the new chemical system of nomenclature.

	Norm	New chemical system
Labradorite-andesite . .	29	30
Rhyodacite	28	26
Trachyandesite . . .	26	27
Dacite	16	18
Labradorite-trachyandesite .	28	27
Andesites	16	16
Bandaites	13	13
Quartz-latite	7	7
Olivine-trachyandesite . .	3	3
Basalts	3	3
Leucite-basanites . . .	—	4
Andesine-basalts . . .	2	2
Olivine-labradorite-andesite .	3	3
Trachybasalts	1	1
Latites	2	2
Soda-trachyte	1	1
Basanites (with Np and Lc) .	3	—
Basanite (with Np) . . .	1	—

TABLE IV. — Comparison between norm (C. I. P. W.) and calculated mode.

N.°		Or	Ab	An	Lc	Ne	Wo	En	Hy	Fo	Fa	Mt	Il
1	Norm . .	19.45	9.42	27.64	—	3.18	12.21	9.02	1.99	2.13	1.00	6.50	1.82
	Mode . .	5.65	15.72	25.02	10.90	—	12.28	7.40	5.68	5.23	2.24	3.48	1.82
14′	Norm . .	24.19	—	17.50	4.64	9.10	14.93	10.14	3.62	5.36	2.10	4.64	1.67
	Mode . .	—	8.38	13.62	24.00	4.54	17.68	11.00	7.66	4.90	2.04	2.32	1.67
17′	Norm . .	26.41	14.38	15.30	2.40	7.82	16.10	11.90	2.63	5.88	1.45	5.80	1.67
	Mode . .	—	9.16	11.40	23.54	2.70	19.17	9.60	7.52	7.70	3.26	3.94	1.67
2	Norm . .	23.62	13.44	28.40	—	2.36	7.83	5.11	2.16	4.89	2.34	5.22	1.82
	Mode . .	15.01	17.29	26.69	6.98	—	9.19	4.70	3.43	5.25	2.55	4.41	1.82
15	Norm . .	22.53	7.58	30.85	—	4.12	8.45	6.80	0.65	3.57	0.38	8.70	2.28
	Mode . .	—	10.88	28.36	17.88	2.34	13.55	7.20	4.88	3.36	1.43	5.33	2.28
16	Norm . .	25.40	29.54	20.85	—	3.07	4.01	2.70	0.99	3.64	1.46	4.87	1.37
	Mode . .	16.54	29.86	20.60	11.46	—	5.04	2.10	2.51	4.20	1.73	3.71	1.37

New names according to the mode for the rocks given in the table:
No. 1 - Leucite basanite (sanidine bearing).
No. 14' - Leucite basanite (to leucite tephrite).
No. 17' - Leucite basanite.
No. 2 - Olivine latite (leucite bearing).
No. 15 - Leucite tephrite (to basanite).
No. 16 - Phonolitic leucite basanite (to leucite bearing latite, with olivine).

SCIENCE COUNCIL OF JAPAN

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Report on Volcanic Activities and Volcanological Studies Concerning Them in Japan during 1948-1951

(With 51 figures)

The volcanic activities in Japan during the period from 1948 to 1951, and the volcanological studies conducted in this period on these activities, mainly from the geophysical standpoints, are given briefly in this report. This report was compiled by the writers on the basis of those original papers and lectures which were made public by the end of 1951. The studies described in this report were made mainly by the Staff of Tokyo University, several other Universities and the Weather Stations located respectively in the neighbourhood of each volcano.

The positions of the volcanoes which were active in the period on question are shown on the map of Fig. 1. Of the activities of these volcanoes, the eruption of Oo-sima was the most remarkable both in the magnitude of phenomena and in the total volume of ejecta.

1. - The Eruption of Oo-sima from July, 1950 to June, 1951.

Oo-sima (Ooshima), an insular volcano which is the largest of the Seven Izu Islands and easy of access, lying about 110km SSW of Tokyo, is well known for its frequent eruptions of the Strombolian type in recorded history [Fig. 1 - (6)].

As will be seen to some extent on the topographical map of Oo-sima, the summit crater, which was 280 m deep and about

300 m in its diametre in 1936, is surrounded by two sommas, the inner and the outer. The inner somma of a quite circular form with a diametre of 700 m and the outer wanting in its northern part is located at a distance of 1-1.5 km in an elliptic form. Accordingly, there are two atrio, the inner and the outer, one between those two sommas and the other between the pit and the inner somma.

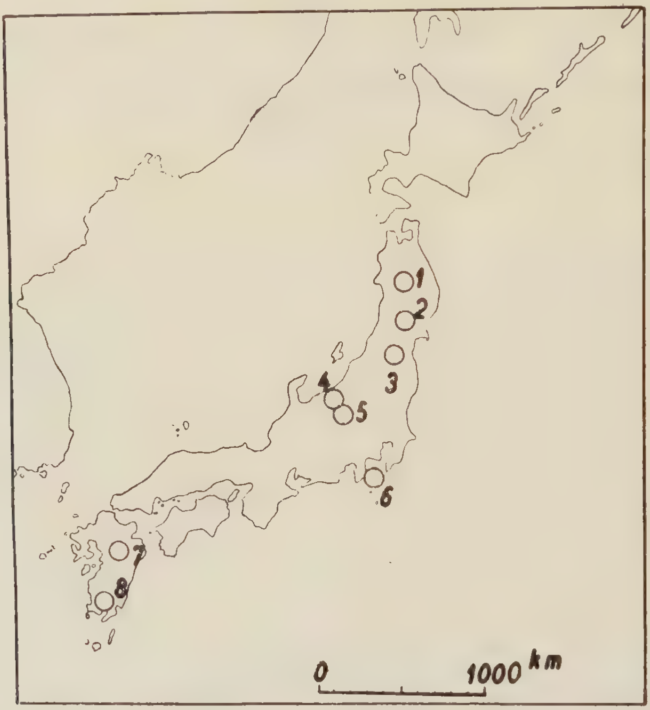

FIG. 1 - Locality of the volcanoes which were active in the period from 1948 to 1951.

According to old chronicles, the outflows of lava over the inner somma took place twice, once during 1684-1690 and once during 1777-1778.

Since the last quarter of the 19th century, many geophysicists have visited the volcano. Among them, however, studies made by R. TAKAHASI and T. NAGATA were most remarkable from the geophysical standpoint, though their investigations were interrupted by the war.

As soon as the present eruption of Oo-sima occurred investigations were made from the geophysical and geological view-points, the main investigators and subjects of their researches being as follows:

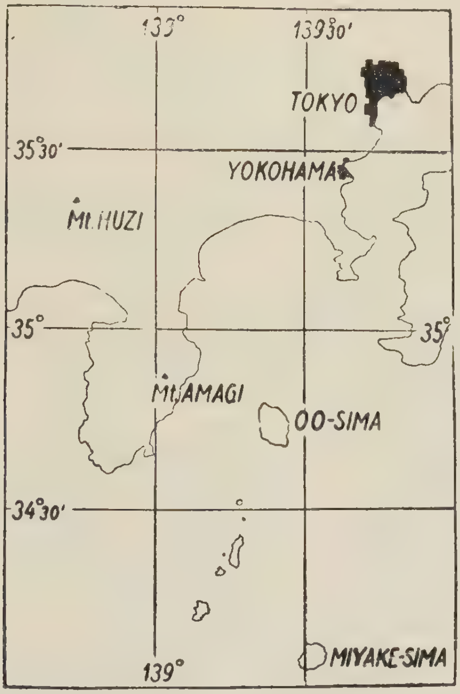

Fig. 2 - Geographical position of Volcano Oo-sima.

(1) Topographical survey near the active crater;
by R. Takahasi, R. Morimoto, D. Shimozuru, K. Hirano and A. Okada (Earthq. Res. Inst.), S. Murauchi (National Science Museum) and Y. Kizawa (Oo-sima Weather Station).

(2) Temperature and viscosity of fresh lava;
by I. Murai and R. Morimoto (Earthq. Res. Inst)., N. Nasu and A. Sugimura (Geol. Inst., Tokyo Univ.)

and S. MURAUCHI in 1950, T. MINAKAMI (Earthq. Res. Inst.) in 1951.

(3) Seismometric investigations;
by T. MINAKAMI and Y. KIZAWA.

(4) Gravimetric Survey;
by K. IIDA and M. HAYAKAWA (Geol. Survey) and A. ZITUKAWA (Earthq. Res. Inst.).

(5) Geomagnetic investigations;
by T. RIKITAKE and I. YOKOYAMA (Earthq. Res. Inst.).

(6) Geology and petrography;
by H. TSUYA and R. MORIMOTO (Earthq. Res. Inst.), A. SUWA (Centr. Met. Obs.) and H. KUNO (Geol. Inst., Tokyo Univ.).

(7) Geochemical investigations;
by I. IWASAKI (Tokyo Inst. Tech.), K. NOGUCHI (Tokyo Metropolitan Univ.) and J. OSSAKA (Earthq. Res. Inst.).

(8) Laboratory experiments on magnetic properties of new lava;
by T. NAGATA (Geophys. Inst., Tokyo Univ.).

1). General Descriptions on the Activities and the Accompanying Topographical Changes.

The pit crater became shallower and shallower after the 1936 activities and was as deep as 170 m just before the present eruption. At about 9h 15m, July 16, 1950, a part of the southern wall of the pit crater went off and incandescent fluidal lava began pouring out with vapour and ash from 20m below the brink of the pit. This was the first announcement of the present activities after a quiescence of ten years. No forerunning phenomenon, such as earth-shakings, roarings or geothermal changes was noticed even near the crater. Though a swarm of earthquakes took place under the volcano towards the end of 1948, it is rather uncertain whether it was the precursor of the activity.

Soon after the commencement of eruption, a new source appeared at the bottom of the pit, which was buried as time went on under the lava from the source and lava fragments. The depth of the bottom lessened rapidly and became 140m on 22nd, 120m on 25th, 60m on 30th, July, and 30m on 11th of the next month.

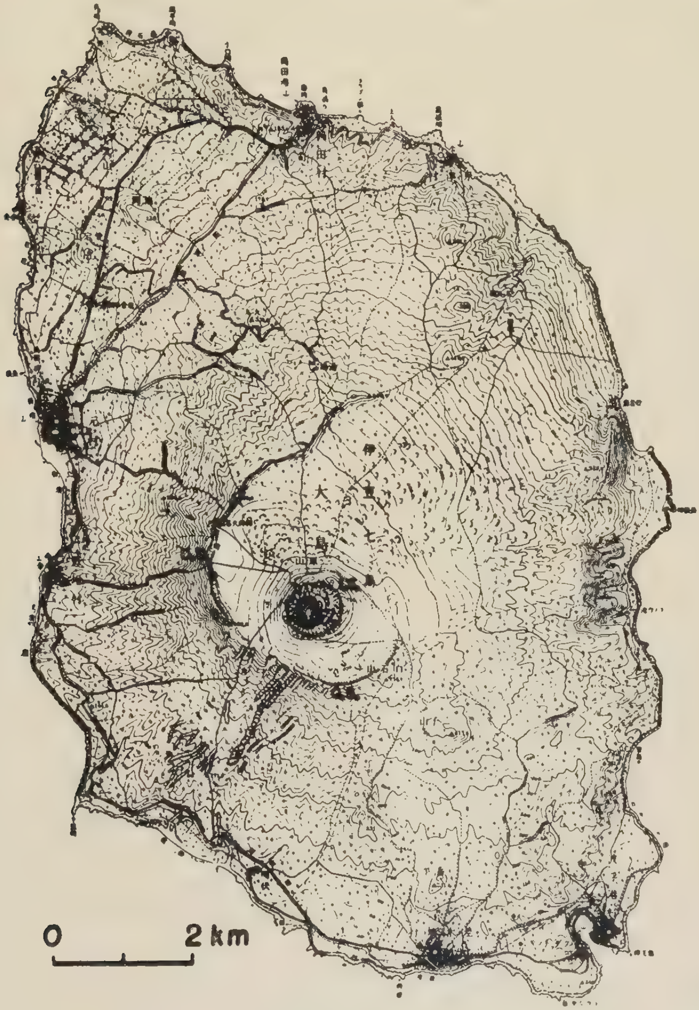

FIG. 3 - Topographical map of Oo-sima.
P; pit crater.
I.S.; inner somma.
O.S.; outer somma.

A new cinder cone- (A), half of which was on the inner atrio and the other half in the pit as debris, was built up by ejected lava fragments and lapilli. Towards August 7, activities of the cone grew intense, hurling red-hot lava fragments 100-200m up above the cone, which was 50m high at that time, and detonations were heard all over the island. A lava stream, 1070°C immediately after the ejection, flowed on August 12 out of a new opening at the southern margin of the former pit. And at last, lava overflowed the pit on August 14 and covered the northwestern half of the inner atrio to a thickness of about 6m. The centre of eruptive activities had shifted about 30m south eastwards by the time, and a new cone-(A') grew up there. On August 21, however, another crater opened on the southeastern skirt of the cone (A') and ejected fluidal lava in forms of both lavaflows and of lava fragments, with a large volume of volcanic gases from the incandescent lava-pool in the crater having a temperature of nearly 1100°C at the surface. Ejecta accumulated rapidly and as the result, another new cone-(B) was built up there in a horseshoe-form, covering the whole of the cone-(A') beneath it. The height of the cone-(B) was 90m above the floor of the inner atrio at the end of August. The lavas which flowed out from the horseshoe-formed crater of cone-(B) covered the southeastern half of the atrio to a thickness of 40-50m by Sept. 1. Towards Sept. 10 the opened part of the horseshoe craterlet was closed with ejecta. After several days a regular form of cinder cone was completed and reached to a height of 754m above the sea level, only 1m lower than the top of the inner somma, on Sept. 23, when the eruption came to an end. The surface of the solidified lava on the western atrio upheaved gradually by the rise of the head of the subsurface lava which welled out from sources at the margin of the former pit crater, and reached the height of 658m above the sea level. On Sept. 13, the first lava-flow flowed down several hundred metres over the northwestern flank of the inner somma, on Sept. 14 over the western side, and on Sept. 19 another lava-flow overflowed the inner somma in its northern part. Their temperature and flowing velocities at the upper flank were estimated at about 1000°C and 6.7 m/min. respectively. Those lava flows were composed of many parallel narrow streams which flowed down side by side successively. Each of the streams was 5-10m in width and about

3m in thickness, and went down through the banks of solidified lava fragments which fell aside at its front. The intensity of explosive activities suffered little change by the night of Sept. 23, when the eruption stopped suddenly. Movement of the lava-flows also came to a stop within the month and the whole of the 1950 activities came to an end.

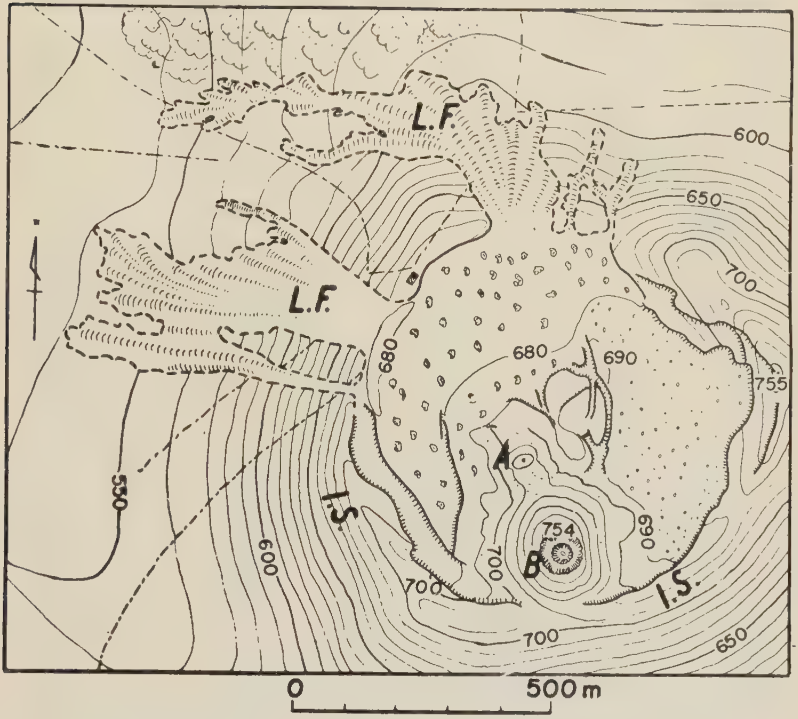

FIG. 4 – Topographical map made soon after the 1950 eruption of Oo-sima.
L.F. the 1950 lava flow,
A.B. cinder cone newly formed in 1950,
I.S. inner somma.
(After R. TAKAHASI and D. SHIMOZURU)

During the period from Sept. 24 to Feb. 3 of the following year the crater was very calm in appearance, though the subsidence of the surface of the solidified lava in the inner atrio, amounting to 2-3m, took place during the last week of September, and was succeeded by a very slight gradual subsidence. The total amount of ejected materials, chiefly in the form of lava-flows which filled up the inner atrio, was estimated at about fifty million tons.

After the quiescence of about four months, Oo-sima resumed its activities on Feb. 4 of 1951 without any noticeable forerunning phenomenon, by ejection of red-hot lava fragments with black smoke from a spot 200m northwest of the cone-(B). The activity was not violent at the beginning and the height of uphurled bombs was about 50m. The eruption got more and more violent as time elapsed and the centre of eruption moved by and by from one craterlet to another, approaching the cone-(B) and at last a new crater opened on the upper part of the northwestern flank of the cone-(B) on Feb. 21. A new cone-(C) grew up around the crater, having buried gradually the former crater, and became the

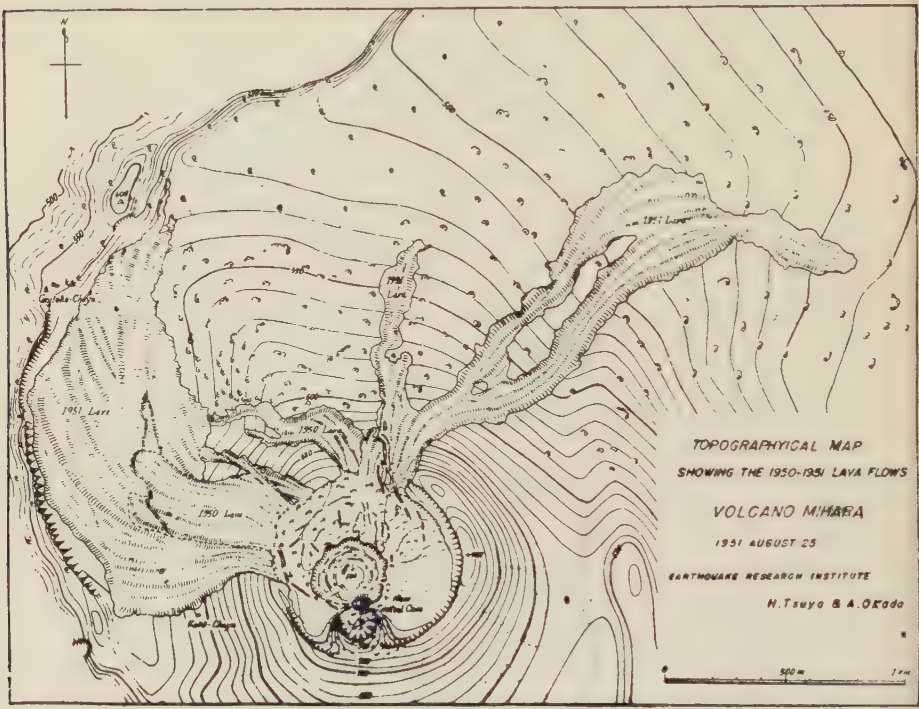

FIG. 5 - Topographical map made soon after the 1951 eruption of Oo-sima. (After H. TSUYA and A. OKADA)

centre of eruptions up to the end of the 1951 activities. Several craterlets mentioned above had steep spatter-cones around them as may be seen in the Hawaiian activity.

After the commencement of eruption the solidified surface of the 1950 lava in the inner atrio began to upheave gradually again, and attained about 3-4m by Feb. 24. On Feb. 28, fresh incandescent lava welled out from the neighbourhood of the margin of the upheaved area, and went down rapidly the northwestern flank of the inner somma. The lavaflows of 1951 was more fluidal than those of the preceding year and flowed with the velocity of 1-3m/sec down the upper flank of which the inclination is nearly 30°. The temperature was about 1100°C there. The lavaflow went further and further on, until its front reached beneath the northwestern wall of the outer somma on March 17. After the date, it turned northwards and almost all of the grand outer atrio which was called « sand sea » was covered by the 1951 lava-flow.

A lava lake, 200m in length and 100m in width, was formed in the northwestern part of the inner atrio by enormous volume of fluidal lava on the 24th and 25th of March. The incandescent lava-lake, above 1100°C in its temperature, splashing and undulating, made a magnificent scene till the end of the month.

During the last decade of March, explosive activity was not so intense and the growth of the cone-(C) was less remarkable. The flight of bombs was 150m at the highest. On March 28, lava-streams flowed down the flank of the inner somma northwards and northeastwards. Eruptive activity once stopped on April 2.

After this repose, the activity became intermittent and paroxysmal, and the intensity of individual explosion grew stronger and the interval of quiescence grew longer as time elapsed. It should be added here that greyish black scorious materials increased greatly in quantity after the middle of April. Main eruptions after April are shown on the following Table 1 with brief descriptions.

Table 1. Eruptions during April-June, 1951.

Date of commencement of eruption	Duration	Remarks
April 2, 19h	1 hour	
3, 10h 46m	1.3 hours	
5, 6h	1 hour	
8		slight smoke several times
9, 0h 30m	short	small
12, 10h	»	»
16, 7h 49m	3.5 days	appearance of two lava-pools in the inner atrio, rapid growth of cone-(C) by paroxysmal eruptions. Height of bombs attained to 250m.
29, evening	1 day	emission of black smoke, sometimes hurling out of lava fragments.
May 3, 0h 40m	5 minutes	
1h 10m	30 minutes	
6, 0h 30m	31 hours	explosive activities of cone-(C), height of bombs 200m. Eastern half of the inner atrio was filled with lava from two fountains in the midst of the atrio.

Date of commencement of eruption	Duration	Remarks
June 9, 12h 30m	27 hours	violent explosive activities from cone-(C), height of bombs 400m. Ejection of lava from several fountains along the foot of the cone, having formed spatter rampart and lava-pools.
14, 22h 20m	15.5 hours	bombs from the cone fell on the flank of the inner somma.
17, 11h 15m	19 hours	height of bombs was 350-400m.
19, 2h	13.5 hours	ejection of bombs as high as 350-400m with strong detonations.
21, 7h 35m	21 hours	bombs flew high with strong detonations and air-shocks. Sound were heard as far as 50km NE.
22, 21h 30m	short	black smoke, fire column.
23, 4h	1.5 hours	several small explosions.
27, 15h 45m	20 hours	furious explosive activities with black smoke column as high as 1,500m.

After the furious activities on June 27-28, Oo-sima remained completely calm throughout the year of 1951. The total amount of ejected lava during 1951 was estimated at about twenthy million tons. The lava which was ejected in 1951 was in the form of the lava-flow on the flank of the inner somma and in the outer atrio.

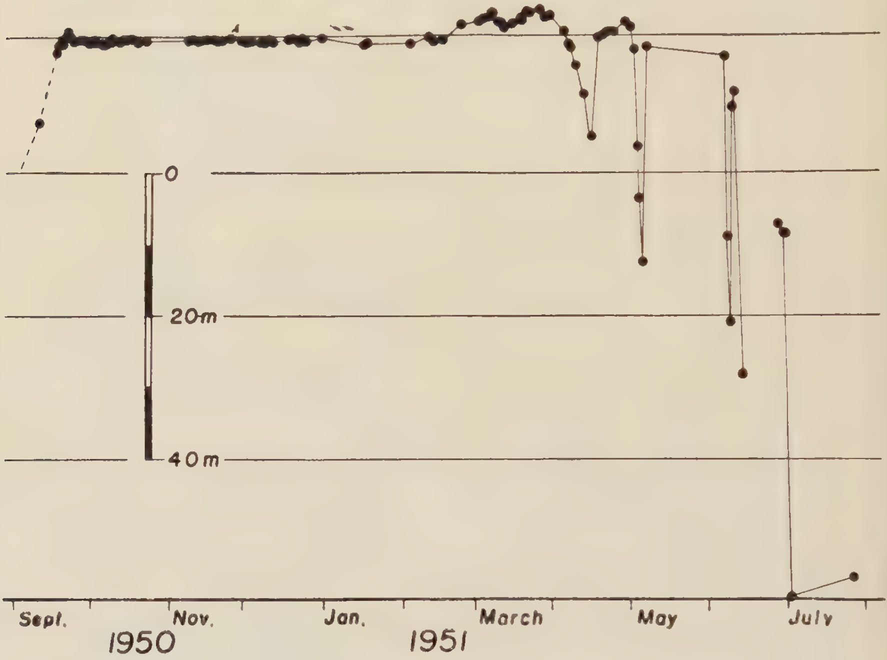

FIG. 6 - Variations in the height of the lava head which appeared at the 1950 - 1951 eruption of Oo-sima.
(After S. MURAUCHI)

The characteristics of the 1951 eruption were at first the appearance of lava-lakes and manifestations of lava-foun'ains, which could be classified into the Hawaiian type. The phenomena can be caused only by gas-rich, fluidal and enormous quantity of lava of high temperature. Besides these phenomena, another rèmarkable characteristic was the changes of topographies inside the inner somma, which accompanied the ebb and flow of the volcanic activities.

From August, 1950, S. MURAUCHI measured frequently the vertical angles to several definite points near the new cone from the outer somma, 2.0km northwest of the cone. He carried out also topographical surveys in the inner somma. The features of the topographical changes were as follows.

After the end of the 1950 activities, the solidified surface of the lava which once filled up the atrio subsided, except in the neighbourhood of the wall of the inner somma. After the 1951 activities commenced, however, the surface began to rise gradually again and its upheaval attained to 3-4m by Feb. 24. This state remained unchanged till the end of March, when the issue of the lava over the inner somma ceased completely. At the beginning of April, the surface began to subside again and the subsidence grew more and more rapid since April 5. As the result, a ring-formed terrace remained around the subsided area, adjacent to the wall of the inner somma. As the subsidence progressed, it came to take place in the limited area which corresponded exactly to the former pit-crater. From the topographical changes we can infer that fresh lava intruded laccolithically under the solidified lava in the inner atrio, pushed ahead the solidified crust, and welled out of weak lines of it near the inner somma during February and March in 1951, and that the lava flowed back into the old pit at the beginning of April.

Preceded by the subsidence, however, an explosive activity took place on April 16, accompanied by an upheaval of the surface of lava together with the accumulation of ejecta and the outflow of fluidal lava. Since then until June, all of the intermittent eminent explosive activities were preceded by similar subsidence which often destroyed the form of the cone-(C). When we compare the amounts of subsidences preceding the respective activities with those of the lavas which were brought to the earth's surface by successive activities in the forms of upheaval and of lava-flows, certain proportional relations may be seen together with a general tendency in both to increase as time went on.

The furious activities at the end of June were followed by a remarkable subsidence after July 1 which formed the present topography.

R. TAKAHASI and others measured in May, 1951 the heights of several triangulation bench-marks in comparison with tide-gauges equipped at three positions of this island. It was reported that no remarkable change was found in the relative height among the bench-marks and that their heights were apparently about 50cm lower than those measured long before the eruption.

2). Temperature and Viscosity of Fresh Lava.

It was already pointed out that the phenomena accompanying volcanic activities, such as earthquakes and crustal deformations, were seriously influenced not only by their magnitude and mode of eruption, but also by physical properties of lavas, especially by their viscosities.

A large volume of fresh lava welled out during the present activities, and measurements of temperature and viscosity were frequently repeated. As will be seen in Table 2, it was made clear that the viscosity coefficient increased greatly with the decrease in temperature and that accordingly precise measurement of temperature, such as by thermo-junctions, is indispensable for discussions of viscosity of lava.

It seems useful to mention the state of the lava-flow which was studied most precisely by T. MINAKAMI. Since the lava-streams in March 1951 were in a molten and incandescent state and a wooden stick could easily be poked into them, it was able to measure not only the temperature of the surface but also that of the interior. The lava-streams from its source to a distance of 300m, including the upper three positions (I, II and III), was molten and in a jelly-like state. However, in the vicinity of position IV, the surface of which is 5°-7°C cooler than its interior, it was covered by a thin layer of gum-like character, 2-3cm in thickness. At the distance of more than 500m from its source its surface came to be covered by solidified lava-blocks of small size, forming the aa-type flow, though the interior was still fluidal, being 1000°C-1030°C in its temperature. Therefore, the flowing velocity at the surface of the middle stream between 300m and 500m from its source was to some extent reduced, as compared with the flowing velocity at a slightly deeper part.

The viscosity coefficient (η) can be calculated by the fol-

Table 2. Viscosity and Temperature of Oo-sima Lavas.

Date	Temperature	Viscosity (η)	Author
1937, Aug	1060° C	5×10^4 c.g.s.	R. TAKAHASI & T. NAGATA
1950, Sept.	1040	1.3×10^5	I. MURAI, N. NASU & A. SUGIMURA
»	1048	3.3×10^7	S. MURAUCHI
»	1063	1.7×10^5	
	by optical pyrometer		
1951, March	1038 (IV)	2.3×10^5	T. MINAKAMI
»	1083 III)	7.1×10^4	
»	1108 (II)	1.8×10^4	
»	1125 (I)	5.6×10^3	
	by thermo-junction		

Table 3. Elements for determining the Viscosity of Lava.

Thickness (a)	Width	Inclinations (φ)	Max. velocity (v)
(I) 31 cm	110 cm	35°	102 ± 8 cm/sec
(II) 50	160	27	35 ± 3
(III) 77	210	16	15 ± 3
(IV) 130	250	11	8 ± 2

lowing formula, in which the section of the flow is replaced by a semi-circle.

$$\eta = \frac{\rho g \sin \varphi}{4 v} a^2$$

K. Kani conducted formerly experiments on viscosity and temperature of various basaltic rocks in the remolten state, including the Oo-sima lava forming the outer somma, of which the chemical composition is almost similar to that of the 1950-lava. A glance at Fig. 7 shows that remolten lava is exceedingly viscous as compared with the lava in the field at the same temperature. It is, however, believed that the discrepancy between the above two cases is mainly caused by the richer content of gas in the lava in natural state.

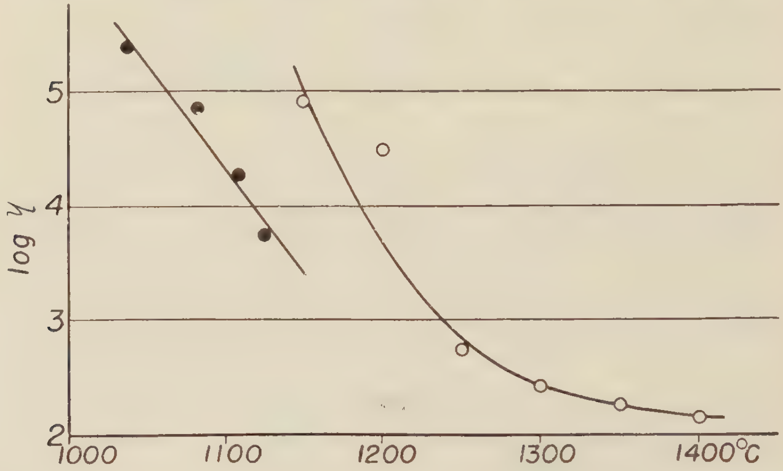

Fig. 7 - Comparison of the present result with the Kani's experiment.
closed circle, the value obtained from the present field investigation,
opened circle, the value obtained from the Kani's experiment.
(After T. Minakami)

T. Minakami proposed in his paper hypothesis concerning the relation of the viscosity of fresh lava with the nature of eruptions of respective volcanoes and their forerunning phenomena.

Kilauea and Mauna-Loa, Oo-sima, Asama, Usu and Pelée were compared with each other from this standpoint.

3). The Pressure which acted under the Oo-sima Volcano in its 1951 Eruption.

The next problem is this; to what degree did the pressure act under the Oo-sima volcano or on the lower end of the conduit connecting the crater with the underground magma? During the period from March 10 to 31, 1951, the molten lava was outpouring incessantly in fountain fashion from two or four sources located near the western summit of the inner somma, of which the diametre was estimated at nearly 1m respecively and their outpouring velocity of molten lava was within a range from 1m per second to 15m per second. From the field investigation these jetlike sources were assumed to be connected with one another at a depth not exceeding several ten metres, forming a large conduit with a diametre of several metres. Moreover, on April 6, 1951, a fountain-like eruption occurred in the central part of the inner-somma, and the height of the lava fountain and the diametre of its jet were estimated at about 10-20m and 3-5m respectively.

However, the pressure (P), which exerted at the lower end of the conduit and which was necessary in ejecting the molten lava in the above mentioned manner, may be expressed as follows;

$$P = P_1 + P_2 + P_3$$

where

$$P_1 = \rho g l_0, \qquad P_2 = \rho g l_1,$$

$$P_3 = \frac{4\eta v (l_0 + l_1)}{a^2} + \frac{1}{2}\rho v_m^2, \quad v_m = \frac{2}{3} v.$$

In the above exprssion, the first term (P_1) of the formula represents the normal ground pressure at the calm state, the second (P_2) indicates the increase of the hydrostatic pressure inside the volcano at the time of eruption and the third (P_3) the dynamical pressure necessary for driving the viscous lava with the mean velocity (v_m) or with the velocity(v) at the central axis of the circular conduit of the diametre 2a.

Concerning the present Oo-sima eruption, the outpouring velocity of the molten lava (v, v_m) the diametre of the conduit (2a), the level difference (l_1) of the lava head at the eruptive stage from the calm stage are given on the basis of the present investigation mentioned above.

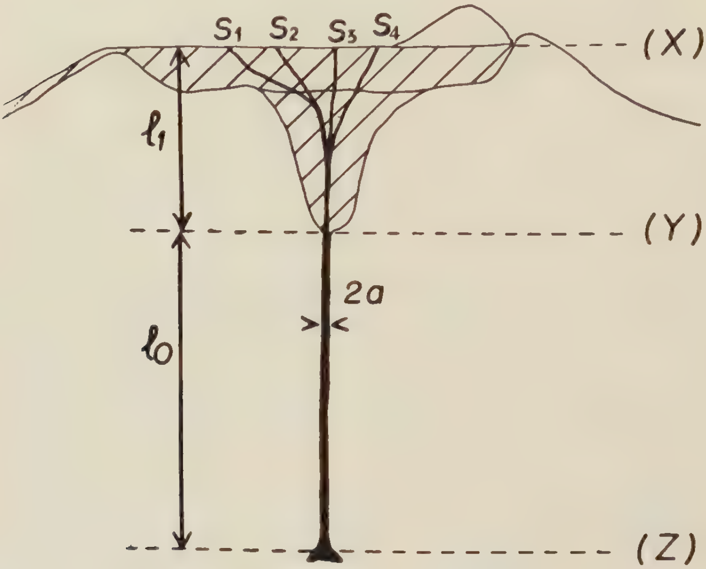

FIG. 8 - Schematic profile of Oo-sima.
X, lava head at the 1950-1951 eruption,
Y, lava head at the calm state (or before the present eruption),
Z, head of lava-reservoir,
S, fountain-like source.
(After T. MINAKAMI)

The values included in the formula (1) are actually taken as follows;

$l_1 = 200\text{m}$, $a=3\text{m}$, $v = 15\text{m/sec.}$, $v_m = 10\text{m/sec.}$,
$\eta = 10^3$ poises, $\rho = 2.5$,
$l_0 = 200\text{m}$ (case I), $l_0 = 300\text{m}$ (case II),
$l_0 = 500\text{m}$ (case III).

Using these values and the formula (1), the pressure acted inside the Oo-sima volcano at the 1951 eruption is calculated for the above three cases, and the result is given in the following table.

Table 4.

Case	P_1	P_2	P_3
I	50 at. pres.	50 at. pres.	4.0 at. pres.
II	75 »	»	4.6 »
III	125 »	»	6.0 »

At a glance of Table 4, it will be clear that the increase of pressure (P_2 and P_3), in the active stage of the Oo-sima eruption, is mainly consumed in form of the rise of the lava head (P_2) and not by the dynamical pressure (P_3). In other words, the latter pressure (P_3) is only one tenth of the former (P_2). The above relation concerning the increase in the hydrostatic pressure estimated from the rise of the lava head and the dynamical pressure both at the time of eruption may be a common character for the Strombolian and Hawaiian eruption.

Although, in the above discussion, the rise of the lava head at the time of eruption is ascribed wholly to the increase in the internal pressure, it will do well to take into consideration the fact that the phenomenon may have been caused partly by the increase in the temperature of lava inside the conduit and below it, and accordingly by the decrease in its viscosity or its internal friction, compared with those at the dormant state.

4). Volcanic Tremors and Earthquakes, Their Characters and Developments.

The three components of seismograph of the Wiechert type at the Oo-sima Weather Station, 5km NWN of the pit crater, recorded no remarkable earthquake and tremor of volcanic origin before the commencement of the eruption. They began to record volcanic tremors, of which the predominant vibrations are 0.6-0.8

second in their period, almost at the same time when the surface activity occurred at first on 9h 15m, July 16, 1950. The tremor was recorded incessantly till the early morning of Sept. 24, a few hours after the sudden cease of the activity in the midnight of Sept. 23. It reappeared with the commencement of the 1951 activities and was recorded almost synchronously with the activities of the crater. Although the amplitude of tremors de-

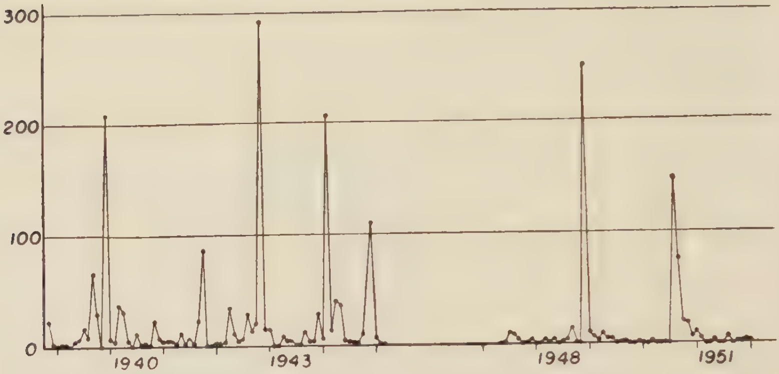

FIG. 9 - Monthly frequency of earthquakes originated from Oo-sima.
(After Y. KIZAWA)

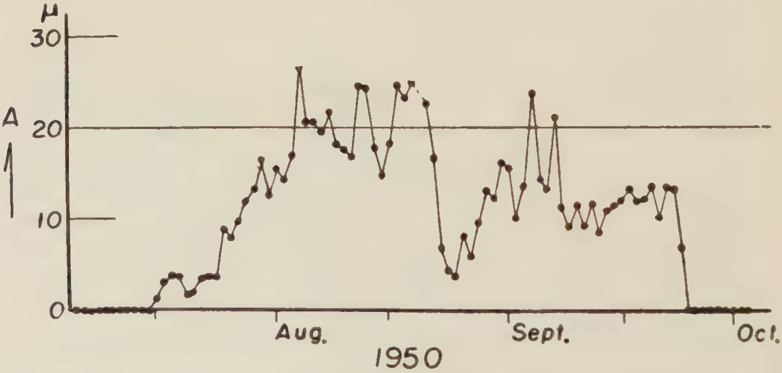

FIG. 10 - Development of volcanic-tremors which were observed in the 1950 eruption at the Oo-sima Weather Station located at 4km from the summit crater.
(After Y. KIZAWA)

pended in most cases on the intensity of paroxysmal eruption, tremors with amplitudes unproportional to the surface activity appeared also sometimes in the present Oo-sima eruption. For example, the amplitude decreased soon after Aug. 21, 1950, when a new crater opened on the flank of the cone-(A'), though the eruptive activity was rather intense at that time.

The earthquakes of ordinary type originating under the volcano took place more frequently than before in the midst of the volcanic activities. The durations of the preliminary tremors of the earthquakes were reported to have been 1-2 seconds at the Oo-sima Weather Station, and they occurred within several kilometres under the volcano. As mentioned above, distinct forerunning earthquakes did not take place as in cases of the activities of andesitic and liparitic volcanoes. This fact, however, does not necessarily deny the possibility of existence of forerunning earthquake in the case of basalt volcano such as Oo-sima, because the problem is concerned with the magnitude of phenomena and the position of the station, sensitivity and characteristics of the instrument.

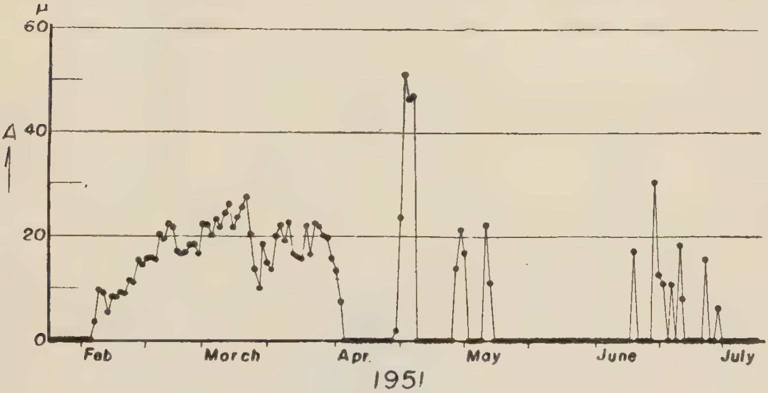

FIG. 11 - The ebb and flow of volcanic tremors which appeared in the 1951 eruption of Oo-sima.
(After Y. KIZAWA)

Those tremors of pulsation type which accompany the Strombolian eruptions such as Oo-sima were often considered to be the successive wave-trains of explosion-earthquakes which accompany explosions every few seconds and propagate one after the other. It is, however, highly probable that vibrations from a somewhat deeper origin may also have been included in the tremors.

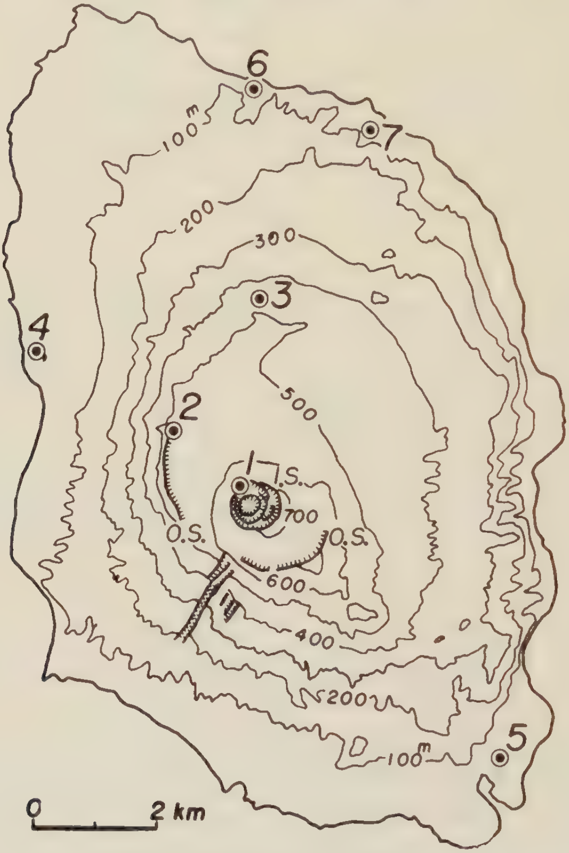

FIG. 12 - Topographical map of Oo-sima.
1-7, position of temporary seismometric stations,
I.S. inner somma.
O.S. outer somma.
(After T. MINAKAMI)

In order to clarify the nature of the tremor, T. MINAKAMI observed it by those seismographs, of which proper period and magnification are adjustable at 1.0 sec and 0.1 sec and 200, 2000 and 4000 times, when necessary.

At first, tremors were recorded at six stations in the island during the last two weeks of the 1950 eruption. Amplitude, period and horizontal orbit were studied. Both the amplitude and the amplitude-period relation were found to suffer little change during the two weeks. Judging from the results shown on Fig. 14, it may be said that the depth of the origin of the volcanic tremor is not more than several hundred metres under the active crater. In studying the propagation of the waves, the following formula is adopted as usual.

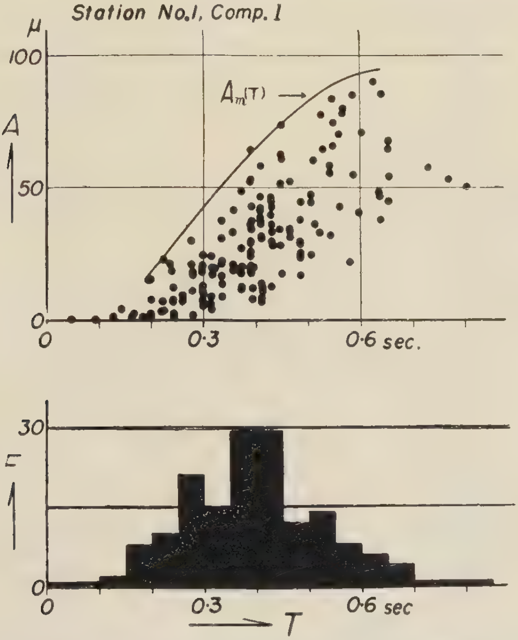

FIG. 13 - Amplitudes (A), vibration-periods (T) and frequencies (F) of volcanic tremors observed at the distance of 0.6km from the active crater.

(After T MINAKAMI)

$$A\,(T,\Delta) = A_0\,(T)\cdot\Delta^{-n}\,exp\left\{-k\,(T)\cdot\Delta + i\frac{2\pi}{T}\left(t-\frac{\Delta}{V}\right)\right\}$$

where A(T, Δ), amplitude of tremor of period T at the distance Δ,

k(T), attenuation coefficient for tremor of period T,

V, propagating velocity of tremor.

Maximum amplitude of tremors for the respective period was compared with each other and n was found to be nearly 1/2. This means that the tremor propagated as surface-waves. Solid-viscosity coefficient could also be calculated from the values of k for the respective periods. The longer the period was the greater became the viscosity coefficient. This phenomenon can be explained consistently if we consider that the vibrations of longer period are affected by the deeper part of the geological formation in comparison with the more rapid vibration, and assume that the extreme

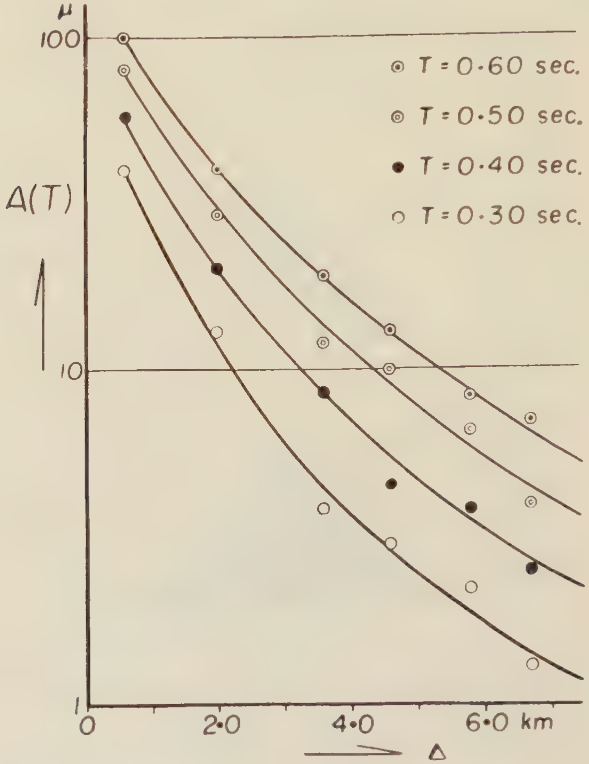

FIG. 14 – The relation between the maximum amplitudes (A) of volcanic tremors and the distance (Δ) from the active crater to the six seismometric stations.
(After T. MINAKAMI and his associates.)

upper parts of the formation of the volcano have apparently smaller solid-viscosity.

Thus the tremor was found to have the nature of surface-waves, but the orbit of the motion of the ground particle was found to be very much complicated. The prevailing direction of vibration did not keep to one direction but changed every few seconds. Consequently, it was impossible to determine the type of the surface-wave from the orbit.

Table 5. Solid Viscosity Coefficient (μ') for Tremors of Various Vibration-Period.

T	μ'
0.60 sec	2.7×10^9 c. g. s.
0.50	2.2 〃
0.40	1.6 〃
0.30	1.0 〃

T. Minakami and Y. Kizawa noticed that the amplitude of tremor is on an average greater in the craterward direction, than that in the transversal direction. Y. Kizawa remarked also that the relative amplitude of tremor in the transversal direction increased at a certain phase of volcanic activities.

T. Minakami and his associates also investigated the nature of the tremor during the 1951 activities. As the result, the following facts were revealed. Firstly, tremors were often recorded on seismograms at 2km NW from the crater even in the period when the crater was calm in appearance. Secondly, these tremors increased both in amplitude and in frequency of occurrence as the eruptive activity approached. Thirdly, the period of the tremors were predominantly 0.2-0.4 sec. during the calm stages, and 0.2-0.7 sec. in the active stage.

On the basis of the present observations, two main origins of tremors are assumed, one at the depth of several hundred metres under the active crater, from which issued the tremors of rather shorter vibration-periods mentioned above, and the other at the extremely shallow place near the head surface of fresh lava column in the active vent, causing the tremors of longer vibration-periods. It is also inferred that the tremors of shorter vibation-periods (0.3-0.4 sec.) and small amplitude originated from the former deep origin during the dormant stage between one eruptive stage and another succeeding one, as seen in Table 1. And in the course of the Strombolian eruption, tremors of short and long vibration-periods ranging from 0.2-0.9 sec. were caused at the two origins with larger amplitude. It must be added that, tremors which had the intermediate characters of these two kinds actually predominated for several hours or several days before and after each eruptive stage mentioned above.

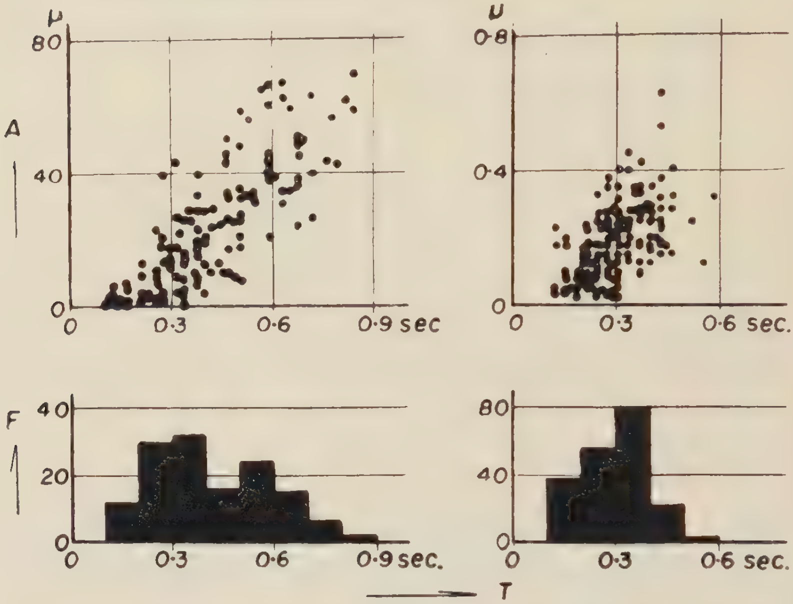

FIG. 15 - Comparison of the natures of tremors observed at the active stage (left) and the dormant stage (right).
A, amplitude, T, vibration-period, F, frequency.
(After T. MINAKAMI)

We may, therefore, reasonably conclude that soon after the effusive activity, the surface origin of tremors sank with the retreat of fresh lava through the conduit of the crater to the position of the deeper origin, and in a similar manner, directly before each eruption or in the course of intrusion of fresh lava, it moved upward in accordance with the rise of the head of fresh lava, gradually causing tremors of longer vibration-periods. In other words, it may be said that one of the origins moves within the conduit and the other is fixed at the depth of several hundred metres, which may agree with the level of fresh lava at the dormant state, or with the lower end of the conduit connecting the crater and the deep seated magma. The problem of the origin and propagation of tremor was thus brought to light to some extent, but the study is yet under way.

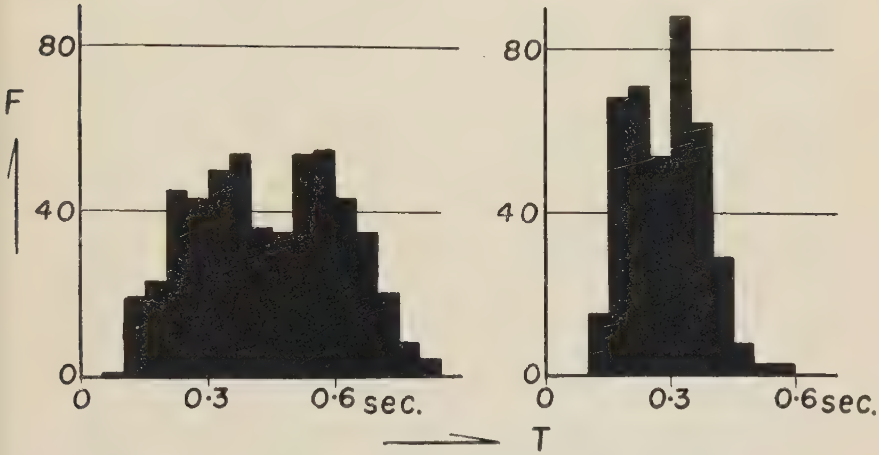

FIG. 16 - Frequency diagrams of tremors for various vibration-periods at the active stage (left) and the dormant stage (right).
(After T. MINAKAMI)

5). Measurement of Gravity.

Though it is remarkable that crustal movements and topographical changes accompany volcanic activities of grand scale, the degree of the changes occurring at the time of volcanic activities in the subterranean mass-distribution is not yet ascertained. The continuous observations, which were formerly made by torsion-balances during the active periods of Komagadake and Asama, failed to supply any positive proof of the existence of change in gravity.

K. IIDA and M. HAYAKAWA repeated four times the survey of gravity on 50 definite points in the Oo-sima Island with the aid of the North-American gravimeter. It was on Sept. 13-17, Nov. 21-26 of 1950, Feb. 20- March 3 and April 9-13 of 1951. The sensitivity of the instrument is 1/100 milligal and errors in observation approximate to this value. Though the effects of astronomical tides and the gradual drift of zero of the suspension spring were excluded, the change in the gravity field on the volcano amounted to 0.4-0.2 milligals at the maximum. Besides, the change in gravity was rather great in the neighbourhood of the active crater, and the gravity seemed to increase during the calm period of the volcano. It is to be remembered, however, that the correction of gravity for altitude amounts to 1 milligal for the change of height of 3m. Accordingly, the change in the height of the observing stations should be investigated precisely. Results of topographical and levelling surveys by TAKAHASI, MURAUCHI and HAYAKAWA were consulted for. The existence of such great changes in altitude corresponding to the changes in gravity could not yet be ascertained. However, in order to justify the above-mentioned changes of gravity, which are suggesting and interesting, other possible effects, such as those caused by the acceleration of the ground vibration during the active period, which was more than 1 gal near the crater, should be thoroughly investigated in future.

A. ZITUKAWA and others also measured gravity at several stations in the island by the Worden gravimeter, but the result is not yet made public.

6). Geomagnetic Investigations.

At the time of the eruption of Miyake-sima in 1940, remarkable changes in the geomagnetic field were discovered by independent observations of several investigators. Since as Oo-sima is akin to Miyake-sima in its type of eruption and in its composing rock, it was expected by Japanese geophysicists that geomagnetic changes would accompany the eruption. T. Rikitake repeated measurements of the geomagnetic elements, especially that of the dip (inclination), and, in addition, carried out continuous observation of the geomagnetic declination at a station in the island. Remarkable change of the geomagnetic field was brought to light by his studies.

(A) *Changes in the Geomagnetic Inclination.*

He measured the inclinations at 36 definite spots form July 25 to 30, from Sept. 22 to 26, 1950 and from March 28 to April 1, 1951 with the aid of the miniature earth-inductor which was constructed by himself. As will be seen in the figure, remarkable decrease in the geomagnetic inclination, 30' at the maximum, took place during the period from July to September in 1950. The nearer the spots were to the active crater, the greater were the anomalous changes. This kind of local change is surprisingly similar to that which occurred at the eruption of Miyake-sima. This change could be fairly well explained by assuming the appearance of an equivalent magnetic dipole 5km under the volcano. The moment was 6.3×10^{14} e.m.u. and the direction was reverse to the present geomagnetic field. With regard to the physical meaning of the appearance of such a dipole, he inferred that the change was caused mainly by the loss of thermo-remanent magnetization, whose intensity was 0.03 e.m.u., within a roughly spherical region of which the centre was situated at a depth of about 5km and the average radius was about 2km. It might be ascribed to the rise of temperature of the underground rocks above their Curie-point by the enormous heat supplied from the subterranean magma.

The changes during the second period were less remarkable, the decrease being 4.6' near the crater where the change was the maximum.

(B) *Magnetic Survey of the Oo-sima Volcano.*

T. Rikitake with his associates carried out a magnetic survey in May, 1951 with the magnetometer of the Geographical

Survey Institute pattern. A geomagnetic chart for 1951.4 in the island was constructed on the basis of these results including the present survey, the survey in 1936 by TAKAHASI and NAGATA and the inclination survey in 1950.

The general tendency of the geomagnetic anomaly agrees well with those of other volcanoes, for example Asama, Huzi (Fuji), Oomuro and others. As already pointed out by Japanese geophysicists, the anomalies in the geomagnetic field near vol-

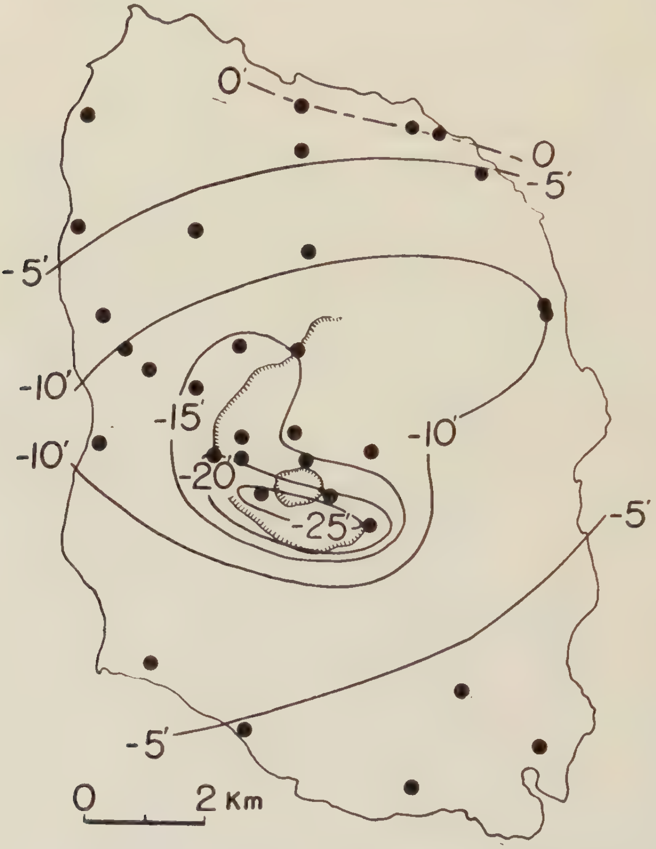

FIG. 17 - Geographical distribution of change in the geomagnetic inclination accompanying the 1950 eruption of Oo-sima.
(After T. RIKITAKE)

canoes may be fairly ascribed to the magnetization of the volcanoes, the direction of magnetization nearly agreeing with the general geomagnetic field there. The mean intensity of magnetization of Oo-sima was calculated at about 0.03 e.m.u. from the anomalies in the inclination.

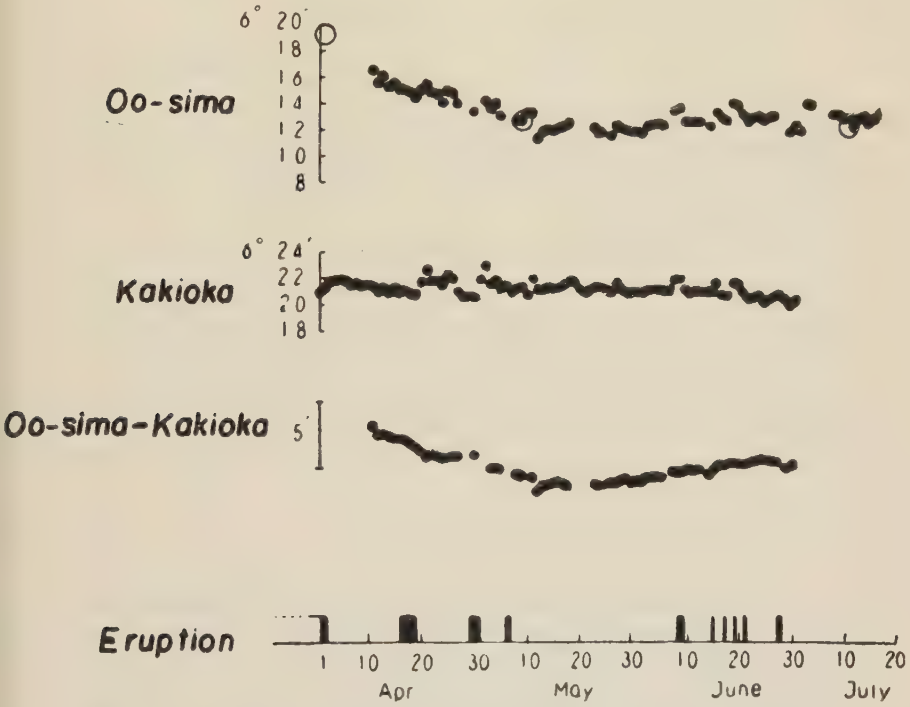

FIG. 18 - Variations in the geomagnetic declination observed at the south-western foot of Oo-sima.
(After T. RIKITAKE)

(C) *The Changes in the Geomagnetic Field in Oo-sima during 1936-1951..*

T. RIKITAKE reoccupied in the course of his survey three stations on which R. TAKAHASI and T. NAGATA measured the three components of the earth's magnetic field in 1936. Taking the general secular variations into account, he concludes that the nature of the anomalous change in the period is approximately expressed by the field of a magnetic dipole whose depth, magnetic moment, direction of the north-seeking end and inclination are 6.1km, 2.8×10^{15} e.m.u., N 18° W and - 17° respectively.

(D) *Continuous Observation of Declination.*

Continuous recording of the geomagnetic declination has been kept on since April, 1951, at the place 4km west of the central crater. On the other hand, absolute measurements of declination were repeated at the place in April, May, June and November of 1951.

As may be seen in the figure, an anomalous decrease in westerly declination of an order of 5′ occurred during the period from the beginning of April to the end of May, while the activity of the volcano became weaker during the period; and the westerly declination turned to increase slightly before the activity in June. The observation has been continued up to this date.

(E) *Geoelectric Studies.*

T. RIKITAKE observed the diffraction of electromagnetic waves at 15 places around the crater in Sept. 24, when the lava in the crater was yet of high temperature. The greatest deviation of the front of propagation amounted to 18° for JOAK broadcast waves. This phenomenon was qualitatively explained by diffraction owing to the lava-mass of high temperature which was electrically highly conductive.

Y. KIZAWA observed the atmospheric electric disturbances originating from the crater.

7). Magnetic Properties of the New Lava of Oo-sima.

T. NAGATA has long been studying magnetic properties and the mode of causation of magnetization of volcanic and sedimentary rocks. Many experimental studies concerning various lavas of Oo-sima were already published. He carried out measurements of magnetic properties of newly erupted lavas in the laboratory. With regard to magnetic susceptibility, an extraordinary Curie-point, perhaps due to the titano-magnetite included, exists besides the ordinary one which is caused by magnetites. The thermo-remanent magnetization is remarkable, and the lava obtains magnetization of 7.3×10^{-2} e.m.u./gr. if the specimen is cooled in the magnetic field of 1 gauss, from the high temperature above the Curie-points down to the room temperature. These properties do not differ essentially from those of the lavas in Oo-sima which flowed out occasionally in recorded history.

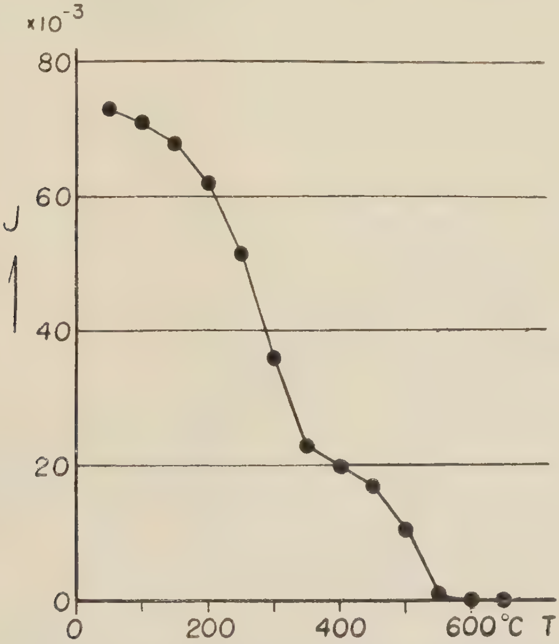

FIG. 19 - Development of the thermo-remanent magnetization of the Oo-sima lava specimen in the process of cooling.
(After T. NAGATA)

The intense magnetization of volcanic rocks gives substantial clue not only to the geomagnetic anomalies in the volcanic districts but also to the geomagnetic changes which accompanied volcanic activities of Miyake-sima in 1940 and the present Oo-sima.

8). Petrological Studies of the erupted material.

General geology and petrography of this volcano were already investigated by S. TSUBOI, H. TSUYA and H. KUNO. H. TSUYA and R. MORIMOTO studied chemically and petrologically the ejecta of each stage of the 1950 eruption and compared them with the formerly obtained results concerning the older lava which formed the volcano.

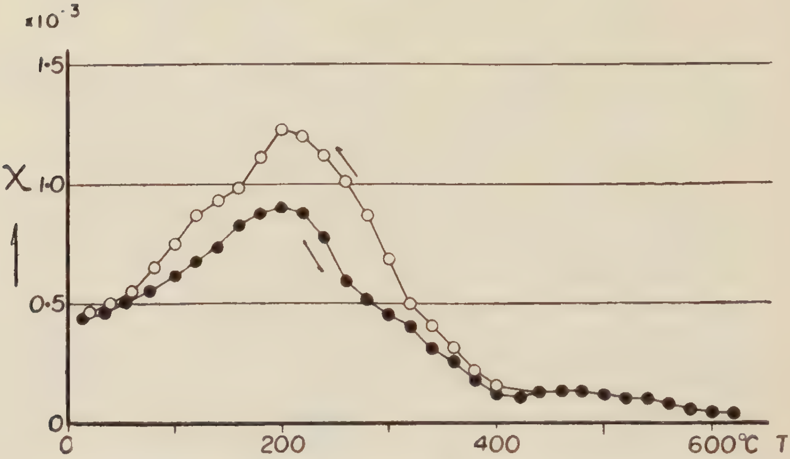

FIG. 20 - Magnetic susceptibility of the 1950 lava specimen at various temperature.
(After T. NAGATA)

According to their researches, both the lava and fragmental ejecta in 1950 are petrologically identified as an uniform augite-hypersthene-bytownite-basalt. Their chemical compositions are shown in the following Table 6. The peculiarity in the chemical composition of lavas which flowed out in historical ages from the volcano is revealed also in the petrochemical features of the present lavas. The high excess of silica in the norm is reflected in the presence of cristobalite in the higher crystalline groundmass. Composition of normative felspars are markedly calcic. High content of iron oxydes and large ratio of total iron to magnesia are also noticeable. The « less-alkaline and more-calcic » property is similar to the rocks of Izu and Hakone volcanoes.

This oversaturated basalt contains anorthite, bytownite, hypersthene and augite as porphyritic minerals scattered in the groundmass composed of bytownite, clinopyroxene, iron ores and brown glass. Cristobalite is found in the higher crystalline por-

Table 6. Chemical Composition of Oo-sima Lavas.

	(A)	(B)	(C)	(D)	(E)
SiO_2	52.68	52.25	52.25	52.53	52.45
Al_2O_3	15.28	15.55	15.33	15.25	13.48
Fe_2O_3	2.78	2.92	3.84	2.69	4.60
FeO	10.56	10.22	9.46	10.57	10.02
MgO	4.59	4.86	4.65	4.54	4.78
CaO	9.78	9.92	9.41	10.76	10.23
Na_2O	1.47	1.72	1.65	1.89	1.99
K_2O	0.26	0.39	0.37	0.43	1.52
$H_2O(+)$	0.20	0.71	0.91	n. d.	n. d.
$H_2O(-)$	0.11	0.21	0.28	—	—
TiO_2	1.67	1.57	1.21	0.74	1.39
P_2O_5	0.17	tr.	n. d.	0.41	0.33
MnO	0.09	0.06	0.15	0.24	0.31
Total	99.64	100.38	99.51	100.05	100.10

where (A); bomb, July 22, 1950,
(B); lava-flow, Sept. 18, 1950,
(C); bomb, Sept. 23, 1950,
(D); Meizi-Taisyo lava, 1910,
(E); An-ei lava, 1777-1778.

tion of the lava. In spite of the variation in the amount of phenocrysts, especially of plagioclase, the rocks are quite uniform in bulk composition.

The studies on 1951 lavas as well on the geological history of the volcano are still in progress.

9). Geochemical Investigations.

Since the lava in the lava-lake is, according to I. IWASAKI, originated from subterranean magma and is in a molten state, it may be called magmatic substance. However we must not regard it as juvenile material just because it includes foreign materials. In the lava-lake, however, foreign materials such as rainwater might have been distilled completely owing to violent and long-lasted emission of volcanic gases. Consequently, he says, volcanic gases observed may be duly regarded to be almost juvenile.

The characters of substances collected by him during March-April, 1951, are described as follows. When the volcanic gas from lava cooled down, a part of it sublimed, a part liquefied and the other remained in an gaseous state. Since most of the volcanic gas consisted of aqueous vapour, soluble materials were dissolved into the water.

(A) *Magmatic Water.*

The water which was in equilibrium with remnant gases was collected by inserting an iron pipe, connected to glass-tubes, 2m deep into a fumarole on the lava-lake which emitted volcanic gases explosively from the interior of high pressure and high temperature. The result is shown on the Table 7. The tendency of more iron and less SO_4 seems to be caused by the iron pipe. The present result is somewhat similar to those of A. L. DAY at the Kilauean lava-pool. The present results differ from the remnant magmatic water in the nepheline-basalt of Hamada. The strong acidity of the magmatic water of the lava-lake was caused by the volatile component which was distilled and collected at the atmospheric pressure. In contrast to that, the nearly neutral magmatic water in the nepheline-basalt may be regarded to be the product of long-lasted reactions between the remnant gases and the surrounding silicates.

Table 7. Character of Magmatic Water.

Acidity	1.4 N
Cl^-	67.6 g/l
S	0.16 g/l
SO_4^-	n. d.
Si	0.090 g/l
Fe	68.9 g/l
Ca	n. d.
Mg	
Ti	
Al	tr. ?

(B) *Volcanic Gas.*

Gases were collected in vacuum glass tubes and were analysed mass-spectroscopically. The result is similar to those at Kilauea, though almost all water-soluble components escaped. Three examples are tabulated as follows.

Radon-contents of gases from fumaroles on the lava-lake were 1-3 mache, and since the quantity of emission of gas was also large, comparatively large quantity of radioactive substances was emitted during the volcanic activities. Considering that the radium-content of Oo-sima lava is $0.9\text{-}0.18 \times 10^{-12}$ g/l, we can imagine that the radon was liberated from a large quantity of rocks by high temperature.

Table 8. Chemical Composition of Volcanic Gases from the Lava-Lake of Oo-sima.

	(B)	(E)	(E)
H_2	12.1	57.1	25.9
N_2	65.4	41.9	72.5
O_2	17.0	0.0	0.0
A	1.2	0.8	0.8
CO_2	4.3	0.2	0.8

(C) *Sublimates or Alternate Substances.*

Various sublimates or alternate materials, white, yellow, brown, red, green and bluish in their colour, were seen around the fumaroles. Gypsum, anhydride, common salt, potassium chloride, and other various complex compounds, containing Cu, Fe, As, or Al respectively, were found up to this date by I. IWASAKI and J. OSSAKA.

2. - Eruptions of Volcano Aso.

Mt. Aso has four craters arranged in a N-S line on the summit, of which the crater most active in recent years, called the first crater, is located at the north end of them [Fig. 1 - (7)].

Observations concerning various volcanic phenomena during 1948-1950 have been made by the staffs of the Aso Weather Station which is located about 1km west of the first crater.

During July-December, 1948, the first crater was more or less active, ejecting volcanic ash with accompanying rumblings, which were however not so violent.

During the period from January 1949 to the later part of December of the same year, the volcano was entirely calm and consequently rain water gathered in several depressions on the bottom of the first crater as well as the other craters. However, on December 26, 1949, eruptions of the Strombolian type began to occur in the first crater, throwing up a great number of incandescent bombs nearly 100m high in the air. The intensity of eruption was at its climax on December 27, when volcanic bombs of 30-40cm in their diametres were ejected up 200-250m high. Paroxysmal eruption lasted for about a month up to the end of January 1950, though its intensity decayed by degree.

In February and April, 1950, the first crater resumed minor eruption of the same nature as mentioned above and during the other months of the year, boiling water remained in the bottom of the crater. The volcano was also active during the period from Nov., 1950 to Jan., 1951 and from June to August, 1951.

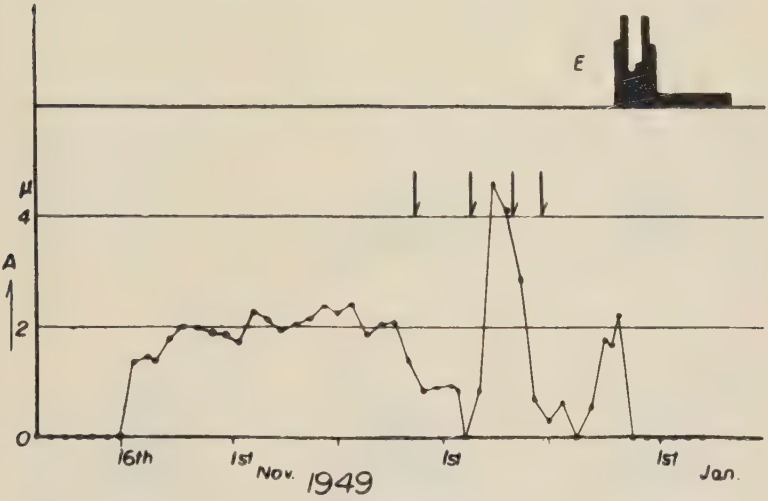

FIG. 21 - Mean amplitudes of volcanic tremors observed during 2 months preceding the 1949-1950 eruption of Aso.
E, intensity of the Strombolian eruption,
arrow, earthquake of ordinary type originated under Mt. Aso.
(After T. TAKEISHI and T. MINAKAMI)

In order to throw light on the question whether earthquakes preceded the eruption or not, T. TAKEISHI in cooperation with T. MINAKAMI carried out seismometrical observations on the summit Observatory. For that purpose, they used a seismograph of high sensitivity of which the magnification was adjusted usually to 360 by means of smoked paper recording and sometimes to 4000 by the aid of optical recording, both being 1.0 second in proper period of vibration.

The seismometrical observation was made during the period from May 1948 to June 1950. Although the seismograph recorded no earthquake of ordinary type from this volcano nor volcanic microtremor during May, 1948-October 15, 1949, remarkable volcanic tremor of the pulsation type appeared continuously during the period from October 16 to December 25, 1949, lasting for 100 days prior to the paroxysmal eruption.

Developments of the volcanic tremors just mentioned are illustrated in a diagram of Fig. 21, through the daily mean amplitudes of volcanic tremors. According to the period-analyses of the tremors, their daily mean values ranged from 0.25 to 0.29 second in the course of the pre-volcanic stage. Therefore, it may be said that the natures of volcanic tremors did not change during the developments of the pre-eruption stage, though their amplitudes showed several cycles of ebb and flow. It must be added that besides those volcanic tremors, earthquakes of ordinary type occurred also under this volcano in pre-volcanic stage mentioned above.

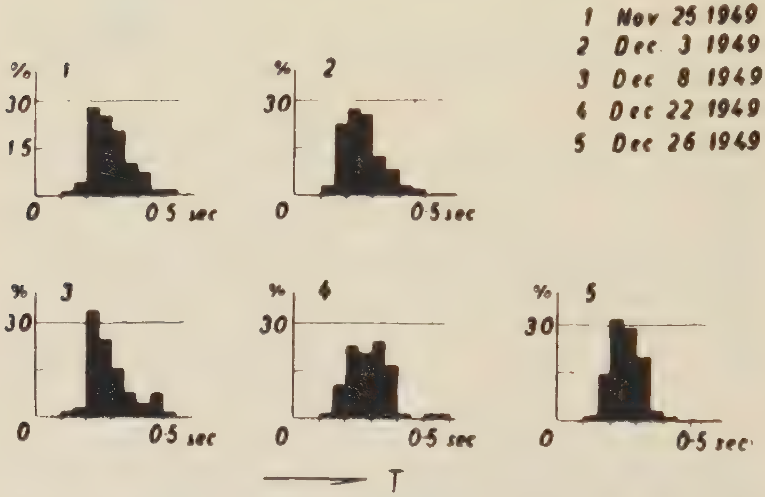

FIG. 22 - Period-analyses of volcanic tremors observed at the pre-volcanic stage of Mt. Aso.
(After T. MINAKAMI and T TAKEISHI)

As was described with respect to the 1950 eruption of Oo-sima in this report, it is well known that one earthquake is accompanied with one volcanic explosion and great number of earthquakes in continuous train are caused by the eruption of the Strombolian type in which explosive eruption of minor intensity occurs every few seconds. In the present Aso eruption also, the seismograph recorded earthquakes of continuous train which were caused by frequent eruptions.

It is quite interesting that remarkable tremors appeared during the three months preceding the Aso eruption of the Strombolian type, when we consider that in many cases of eruptions of the Vulcanian type in the andesite or dacite volcanoes such as Usu and Asama etc. in Japan, numerous earthquakes of the ordinary type, not of the pulsation type, took place prior to their paroxysmal eruptions, as reported at the 1948 assembly of I.U.G.G. at Oslo.

3. - Minor Eruption of Sakura - zima.

During the period from January to June 1950, Sakura-zima which erupted and welled up large volume of fresh lava in March and April 1946, was in a calm state and we had no information concerning noticeable volcanic phenomena of Sakura-zima. However, paroxysmal eruptions took place on July 4, 5, 19, 22, 24, 25 and on August 9, 10, 1950, though they were not so violent. Volcanic ash which is believed to have originated from fresh lava, fell on the streets of Kagosima city, 11km distant from the crater [Fig. 1 - (8)].

4. - Explosive Activities of Volcano Asama.

Eruptions of Mt. Asama are of the Vulcanian type in their nature which is characterized by ejection of a large amount of incandescent lava in a moment in form of lava blocks and bombs with fine ejecta and vapour [Fig. 1 - (5)].

The Asama volcano was active during August-September, 1949, and September-October, 1950, of which the paroxysmal eruption on September 23, 1950 was most remarkable in the volume of ejecta as well as in the earthquake caused by the explosion. In addition, the explosion was accompanied with furious detonation, or in other words, strong air vibrations, which caused serious damage to window-panes of dwelling houses and schools located at its skirt within 20km from the summit crater.

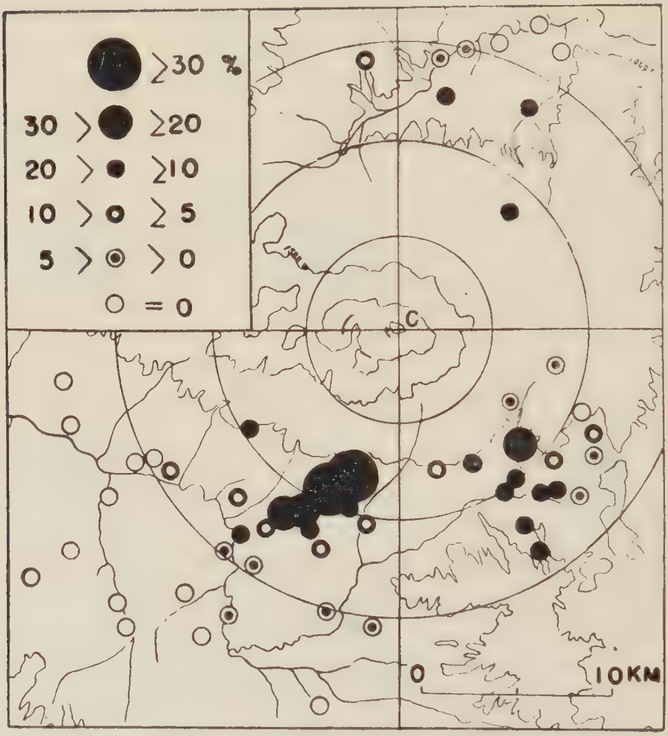

FIG. 23 - Geographical distribution of average damage-percentage of window-panes for the villages located at the skirt of Mt. Asama.
(After S. SAKUMA)

S. SAKUMA studied the nature of the air-shocks on the basis of the damage. Having compared this phenomenon to the damage done to windows by the atomic bomb which fell on Hirosima, he concluded that the amplitude of initial compressional phase of the air-shock migth have been $1\text{-}2 \times 10^{2}$ atmospheric pressures at the distance of 18km from the crater.

The detonation including high and low frequencies of air vibrations was so strong that it was heard at localities more distant than 200km from this volcano, and according to the investigation of the Central Meteorological Obsrvatory, as is shown on the map of Fig. 24, the sound area was divided into the inner and outer zones as has been usually experienced in the cases of strong detonations from various sources.

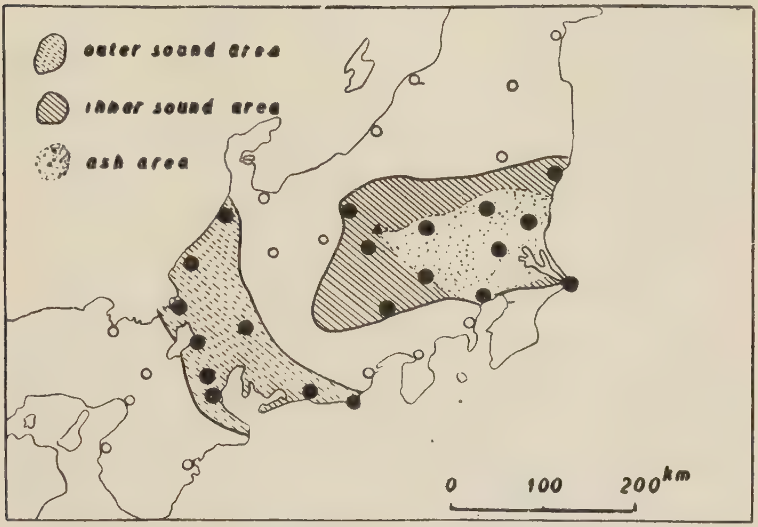

Fig. 24 - Geographical distribution of the detonation and volcanic ash from the explosion on September 23, 1950.
(After Central Meteorological Observatory)

From the intensity scale based on the earthquake-motions caused by this explosion, its kinetic energy was estimated at 10^{20} ergs which was one of the most strong explosions in the recent thirty years.

The explosion earthquake which accompanied the eruption was recorded by seismographs of 12 Weather Stations as far as 185km from the volcano. T. MINAKAMI carried out seismometric investigations on the basis of not only the present data but also those of the past eruptions. Though the study is now under way, the following results were already obtained. The initial motion of the explosion-earthquake is predominantly « push ». At least three layers were found to exist beneath central Japan, in which the velocities of P-waves were found to be about 3.7, 5.4 and 6.1 km/sec. respectively, from the analysis of travel-times of waves.

On October 4, another explosion took place with strong detonations which were heard as far as 180km from the volcano.

As reported in the previous meeting of our Association at Oslo, various volcanic phenomena have been studied at the Asama Volcano Observatory (E.R.I.) since 1934, on the basis of the instrumental observations concerning earthquakes and microtremors of volcanic origin, the crustal deformations near Asama, and other phenomena.

5. - Explosive Activity of Volcano Yake-yama.

Mt. Yake-yama broke out in sudden explosion on the fifth of February, 1949, after a 95 years period of quiescence since 1854. This was followed by another explosion on the seventh of the same month. In the first explosion, the volcanic ash was blown off southeastwards and fell on the snow-covered-ground of the lee side, but there was no eruption of lava stream through the entire period of the present activity [Fig. 1 - (4)].

Soon after the present activity of this volcano, H. TSUYA, T. ICHIMURA, T. SHIRAI and R. MORIMOTO from the geological and geochemical standpoints, and T. MINAKAMI and S. SAKUMA from the geophysical view-points studied the eruption of this volcano.

Although earthquakes usually take place under volcanoes prior to and in the course of eruption in which fresh lava is extruded, it is also interesting to investigate whether earthquakes occur or not under the volcano in such a minor activity of fumarolic type ejecting no fresh lava as in the present case of Yake-yama. For this purpose, a seismograph of high sensitivity was set at two temporary stations at the foot of the mountain and was operated for two months soon after the first explosion. As the result of these seismometrical observations it became clear that ten several non-perceptible earthquakes took place under this volcano and in its vicinity, and judging from the shapes of seismograms and the nature of their earthquake-motions, some of those earthquakes originated from a depth of 2-5km under the mountain and others from extremely shallow hypocentres less than 1km. Therefore, it may be reasonable to consider that the present activity of Yake-yama had also its source of the effusive energy at a depth of several kilometres under the earth's surface, though no fresh lava was extruded at all.

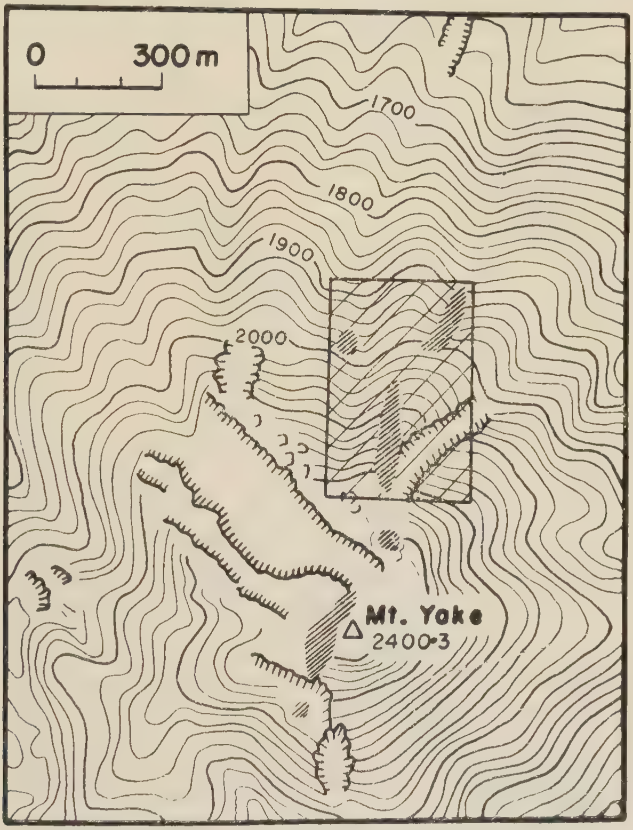

FIG. 25 - Topographical map of Mt. Yake-yama including its summit and the area active in 1949.
(After S. SAKUMA and T. MINAKAMI)

Positions of craterlets and fissures both newly formed on the flank of this volcano were surveyed by means of triangulation.

As is shown on the map of Figs. 25 and 26, the newly opened craterlets and fissures are aligned on the several lines running towards N 10°-30° W and as a whole in a narrow zone towards N 20° W, which is about 150m wide and 1km long and cutting across the eastern wall of the older summit crater. Water vapour and volcanic gas were being emitted from some of these craterlets and fissures up to the present (Dec. 1950), of which the maximum temperature was measured at 94°.5 C in August 1949.

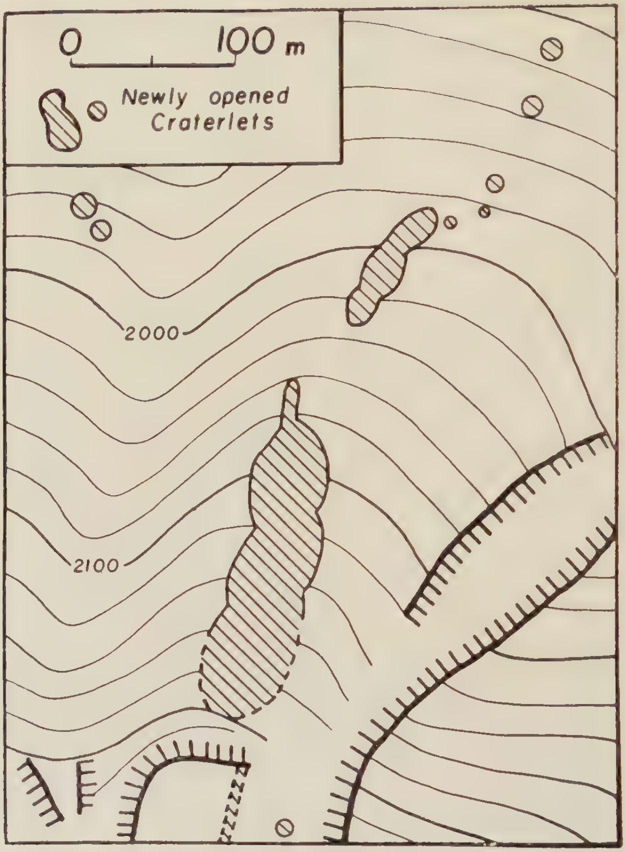

FIG. 26 - Topographical map of the craterlets newly opened at the northern flank of Yake-yama
(After S. SAKUMA and T. MINAKAMI)

Rocks around most of the fumaroles were covered thickly with sublimates consisting principally of white fibrous minerals, besides sulphur. Two samples, one of which was collected from a fumarole on the summit and the other from a fumarole on the northern flank of the volcano, were analyzed chemically with results as follows.

Table 9. Composition of Hydrated Aluminum-sulphate Minerals.

	Al_2O_3	SO_3	H_2O	FeO	other components
Sample I	10.5	32.1	52.1	4.5	CaO 0.2 As_2O_3 0.3,
Sample II	13.5	33.0	50.2	2.5	Al tr. Cl tr.

6. - Fumarolic Activity of Volcano Azuma.

During May and July, 1893, the Azuma volcano erupted strongly and formed five craterlets on the flank of its main cone.

Since the 1893 eruption, we had no information concerning the volcanic activity of Mt. Azuma for the subsequent 57 years.

On the 10th of February, 1950, fumarolic explosions took place with ejection of ash and volcanic detritus, but no ejecta from fresh lava were found as in the cases of the former activities of this volcano on record [Fig. 1 - (3)].

In the present eruption, numerous craterlets including those of extremely small sizes were newly opened along the main fissure and several small ones in the neighbourhood of the 1893 craters. Ash and fine fragments of detritus blown up in the air by these explosions fell on the south-eastern flank of the mountain and on the other hand, ejecta of the larger size of 30-60cm in their diametres fell mainly on the ground within a distance of 600m at the south-eastern side of the newly formed craterlets.

As soon as the first explosion occurred, T. Minakami with his associates and the staff of the Hukusima Weather Station located near this volcano set a seismograph at Tutiyu spa, S-E 13km and at Nuruyu spa, E 5 km both measured from the active craterlets on the summit. Notwithstanding the fact that the seismographs used were as highly sensitive as those used in the cases of Mt. Yake-yama and Mt. Aso, no earthquake of volcanic origin was observed during the period from February 15 to the end of March 1950. Judging from the result of the seismometric observations and the nature of eruption, it may be concluded that the present explosions of Volcano Azuma were of geyser-like phenomena near the earth's surface, and were not ori-

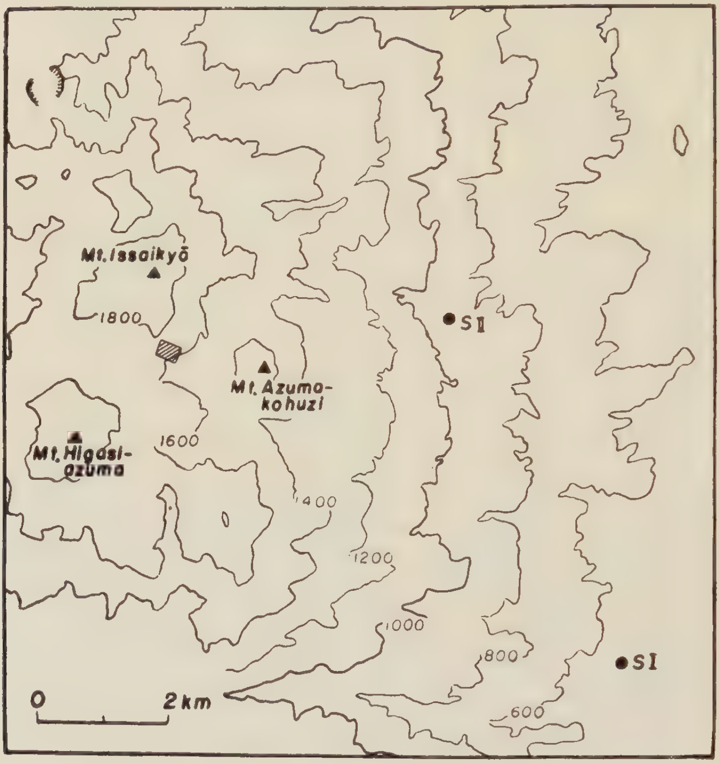

FIG. 27 - Topographical map of Mt. Azuma and its vicinity.
SI, SII, temporary seismometric stations;
hatched area, position of the newly opened fissures. (Fig. 28).
(After T. MINAKAMI)

ginated directly from the effusive force of the magma which is deeply seated under the volcano.

To determine the precise position of the newly formed craterlets, a topographical survey was executed in July, 1950, as is shown on the map in Fig. 28. Simultaneously, the inclination of the geomagnetic field was measured at several points on the summit, flank and skirt of the mountain, and the intensity of

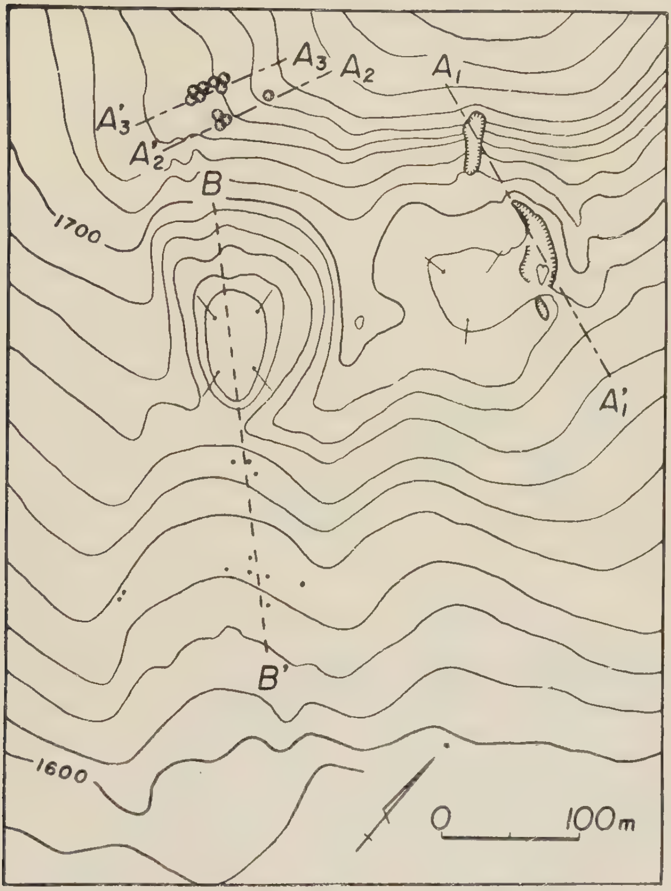

FIG. 28. - Topographical map near the craterlets newly opened on Mt. Azuma.
$A_1A'_1$, $A_2A'_2$, $A_3A'_3$, fissures formed in 1950,
B B', fissure active in 1893.
(After T. MINAKAMI and S. HIRAGA)

magnetization of this volcano was studied on the basis of anomalous distribution of the magnetic inclination. As the result of that, it was elucidated that the intensity and mode of magnetization are of the usual manner of andesite volcanoes in Japan such as Asama, Sakura-zima and Yake-yama etc.

7. - Fumarolic Activity of Volcanoes Akita - Yakeyama and Kurikoma.

Towards 14 h, August 30, 1949, Mt. Akita-Yakeyama broke out in form of steam explosion and was followed by another explosion on the following day. Rumblings were heard simultaneously at the foot of the mountain, 6km distant from the active crater. Ash and fragmental detritus of the older formation of this volcano were thrown out at these outbursts and accumulated on the margin of the crater, but no fresh lava was erupted in any form of ejecta [Fig. 1 - (1)].

Mt. Kurikoma showed several series of fumarolic activities of minor scale during 1948-1950, but precise investigation concerning these eruptions was not carried out [Fig. 1 - (2)].

LIST OF VOLCANO OBSERVATORIES IN JAPAN

Observation of volcanic phenomena, mainly from geophysical standpoints, is continuously carried out by the following Volcano observatories and other Weather Stations near by. At the time of remarkable eruptions, expedition parties are sent from Earthquake Research Institute and other organizations.

1) Asama Volcano Observatory (Earthq. Res. Inst., Tokyo Univ.)
   4.2km E of the central crater of Asama, with three branch stations around the volcano.
   Established in 1933.
2) Aso Volcanological Laboratory (Kyoto Univ.)
   8km W of the active crater of Aso.
   Established in 1929.

3) Weather Stations in the neighbourhood of volcanoes (under jurisdiction of Centr. Meteor. Obs.)
Asama; Karuizawa Weather Station,
Aso; Aso Weather Station,
Sakura-zima; Kagosima Weather Station,
Oo-sima; Oo-sima Weather Station,
Tori-sima; Tori-sima Weather Station.

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PLATES

Fig. 29 - Fig. 44,	Volcano Oo-sima.
Fig. 45,	Volcano Aso.
Fig. 46 - Fig. 47,	Volcano Yake-yama.
Fig. 48 - Fig. 49,	Volcano Azuma.
Fig. 50 - Fig. 51,	Seismograms.

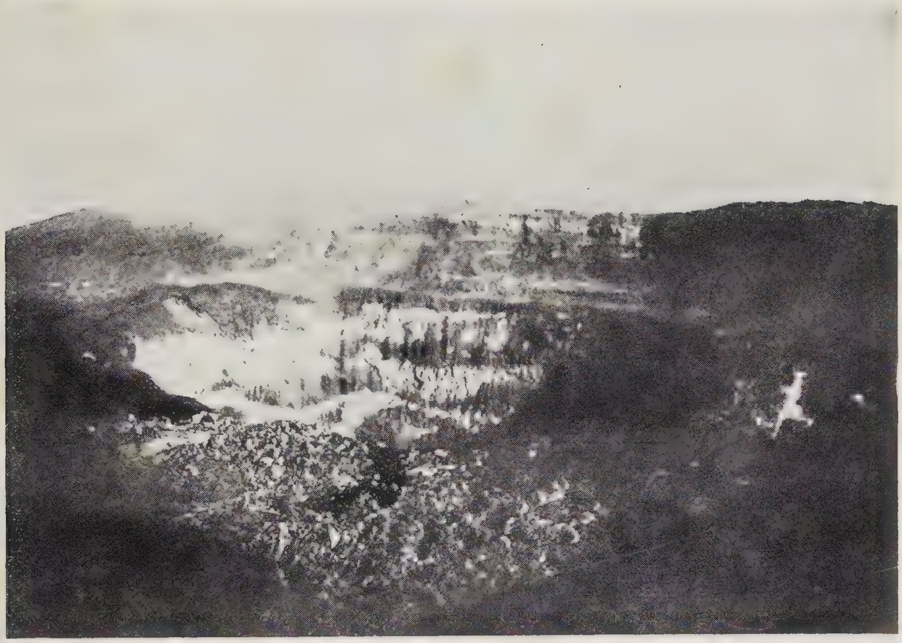

Fig. 29 - The pit crater and the inner somma before the 1950 eruption. (After S. WATANABE)

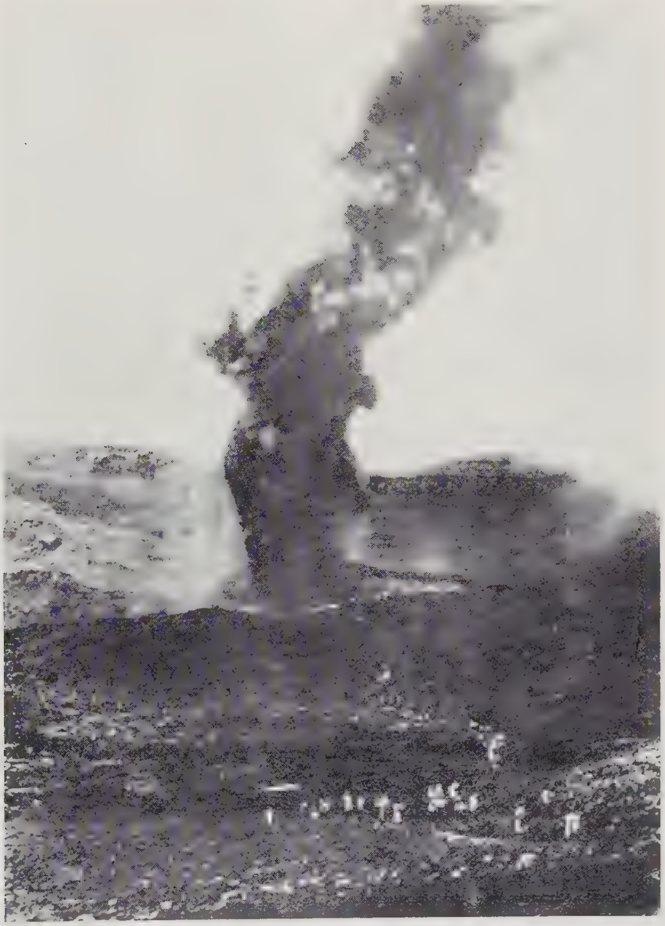

Fig. 30 - Eruption from the pit crater at the beginning of the 1950 eruption. (After S. WATANABE)

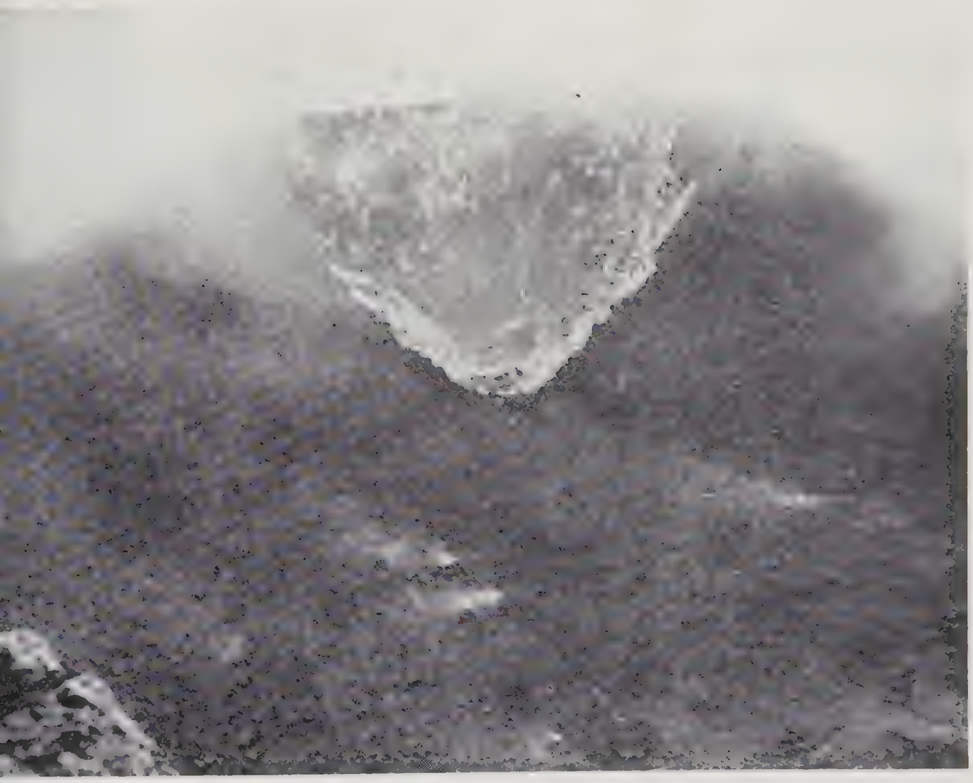

Fig. 31 - Paroxysmal eruption in the craterlet B on Aug. 30, 1950.
(After S Murauchi)

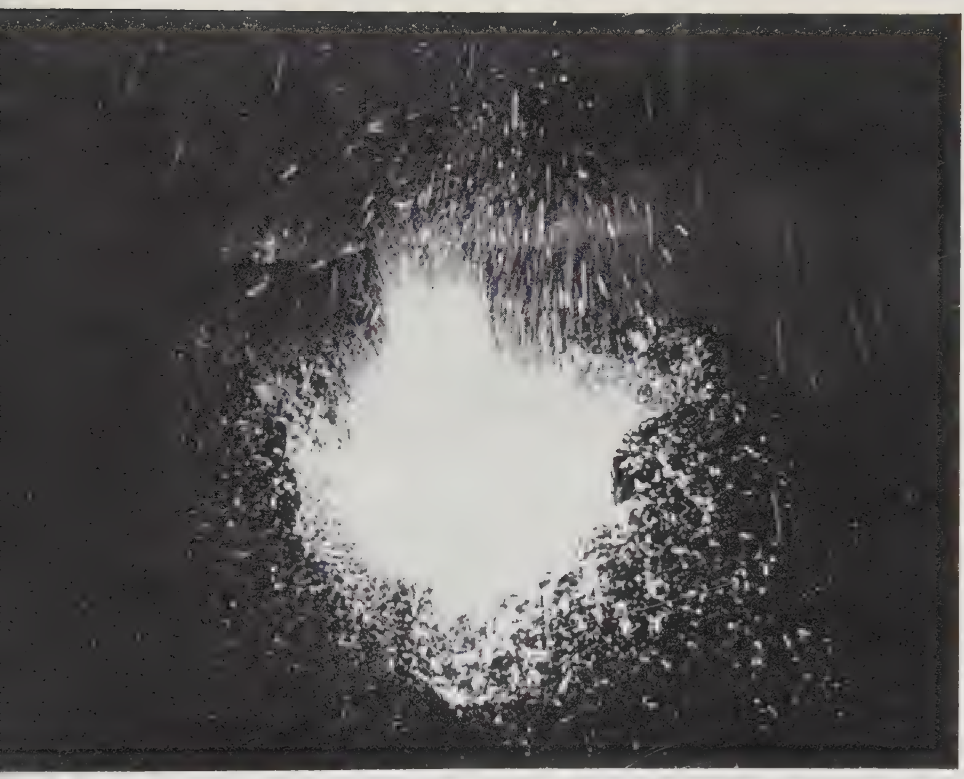

Fig. 32 - Paroxysmal eruption in the craterlet B on Aug. 30, 1950.
(After S. Murauchi)

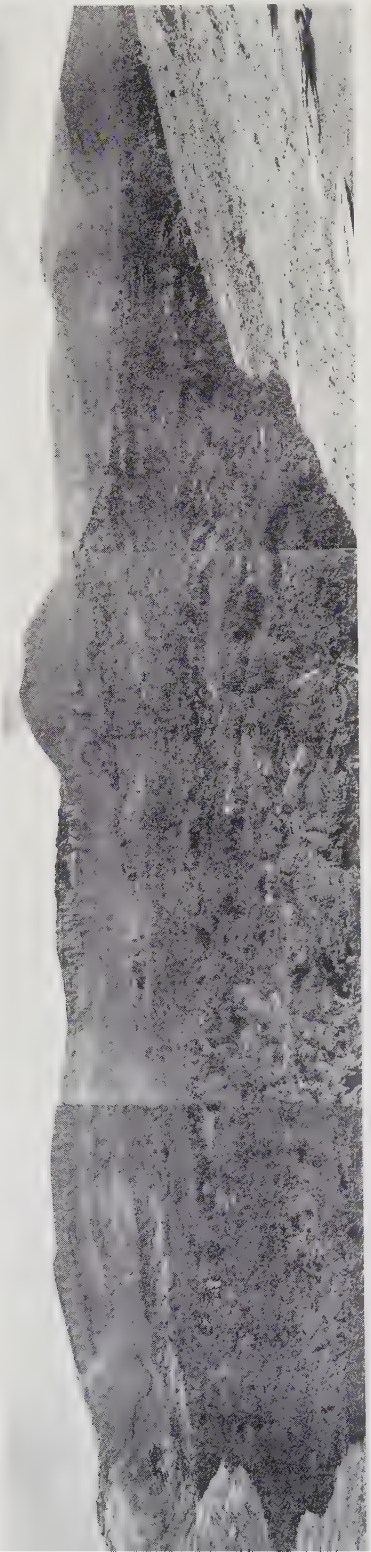

Fig. 33 - The fresh lava filled the inside of the inner somma, on Sept. 10, 1950.
(After S. WATANABE)

Fig. 34 - The 1950 and 1951 lava buried the atrio surrounded by the western outer somma.
(After T. MINAKAMI)

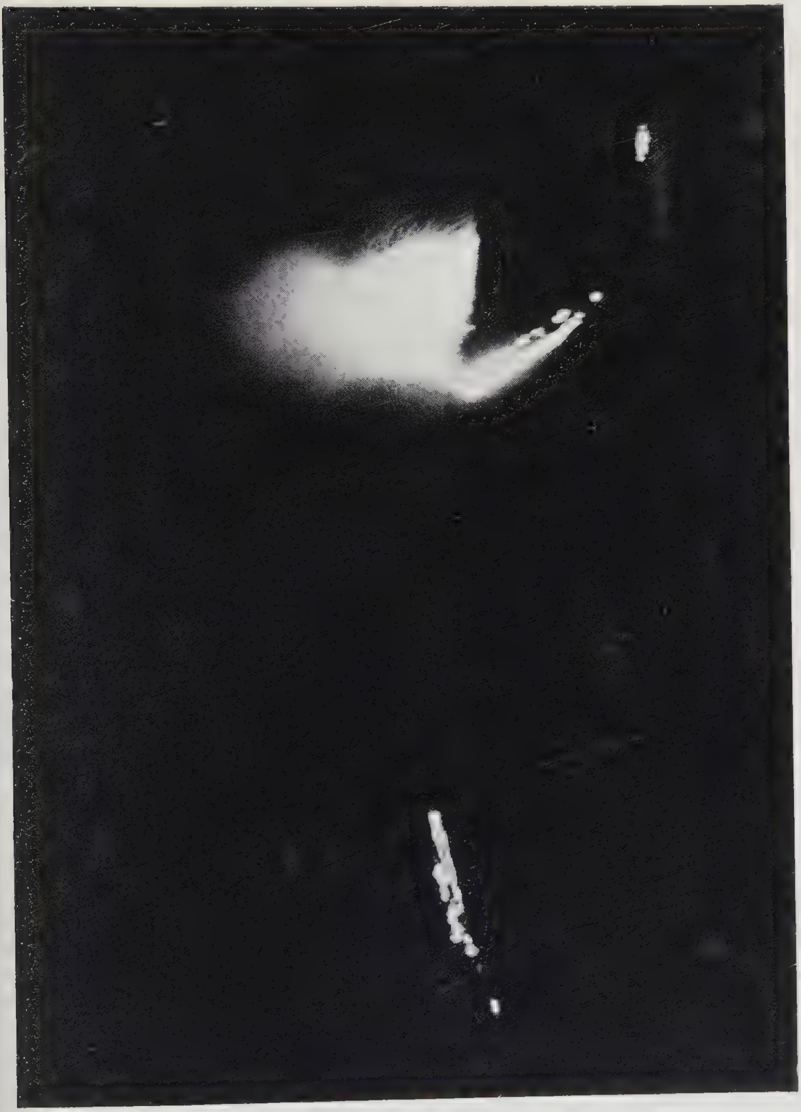

Fig. 35 - The night view of the Oo-sima eruption on Sept. 16, 1950.
(After T. MINAKAMI)

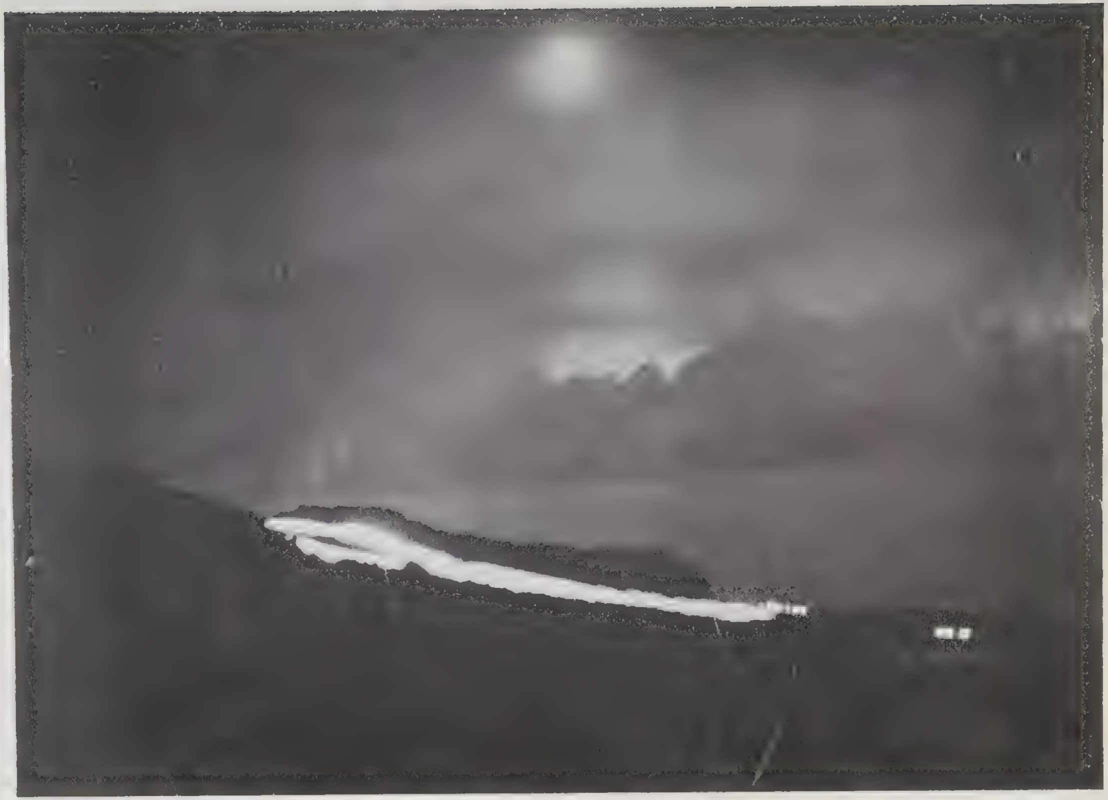

Fig. 36 - A lava stream flowing the flank of the inner somma on Sept. 16, 1950.
(After T. MINAKAMI)

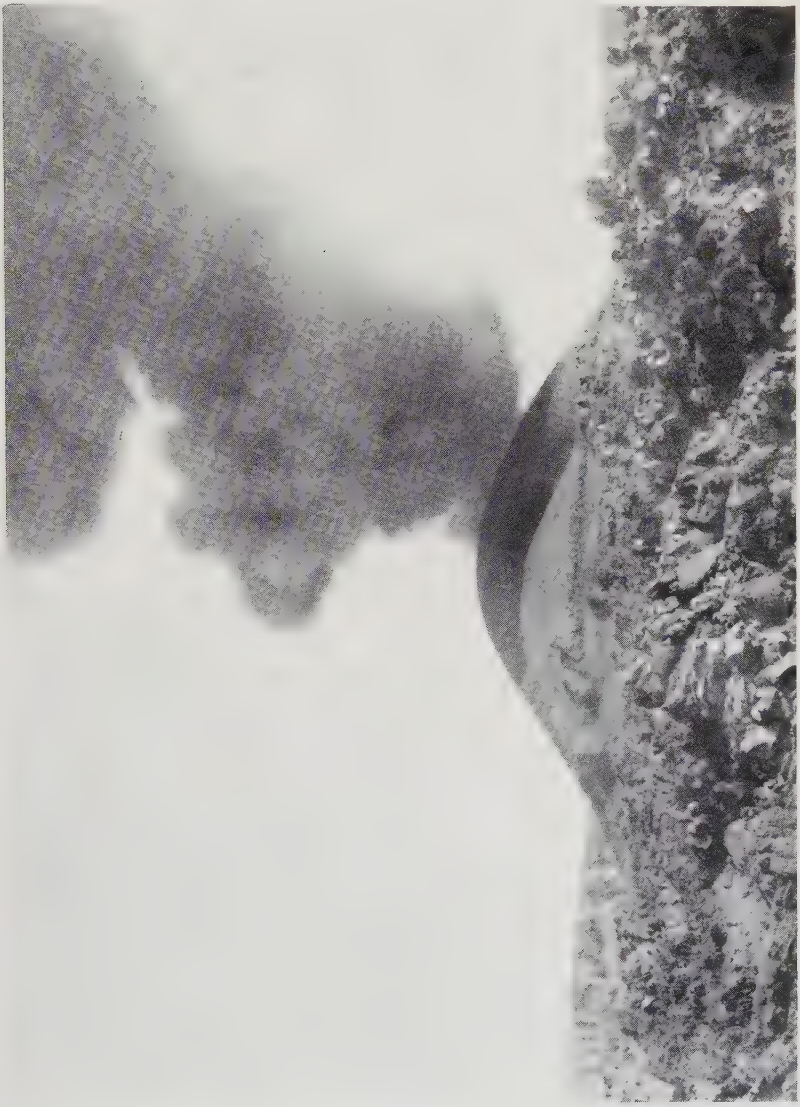

Fig. 37 - The cinder cone-(B) newly formed at the 1950 eruption. (September 16, 1950).
(After T. MINAKAMI)

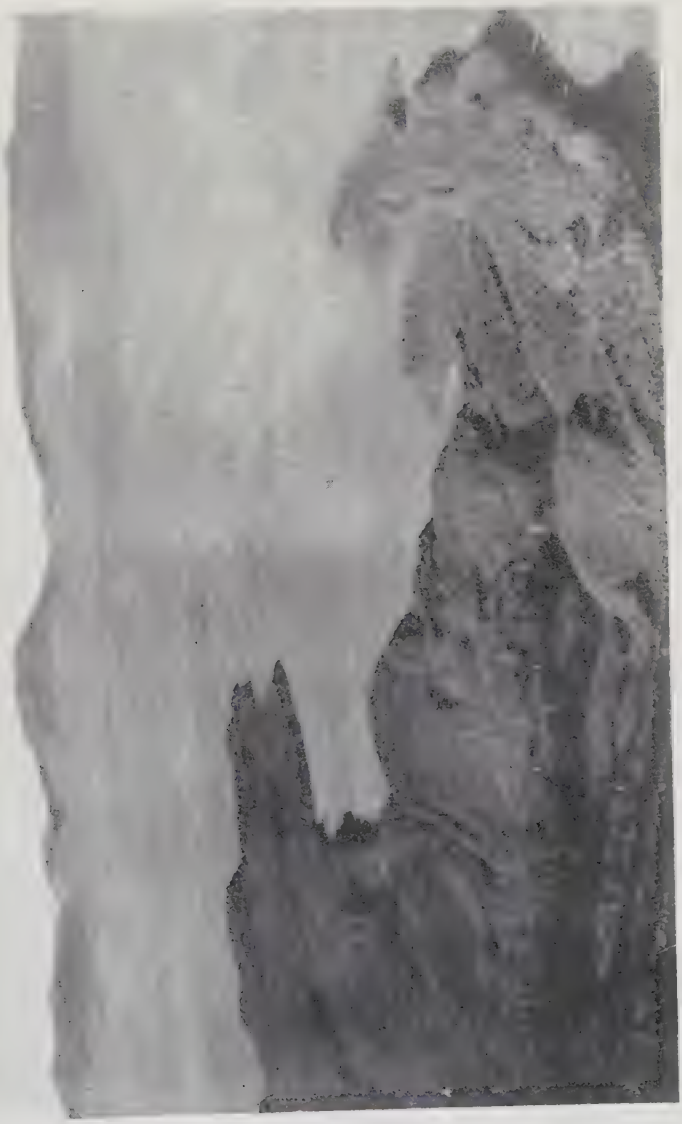

Fig. 38 - The 1950 lava flow seen from the inner somma.
(After T. MINAKAMI)

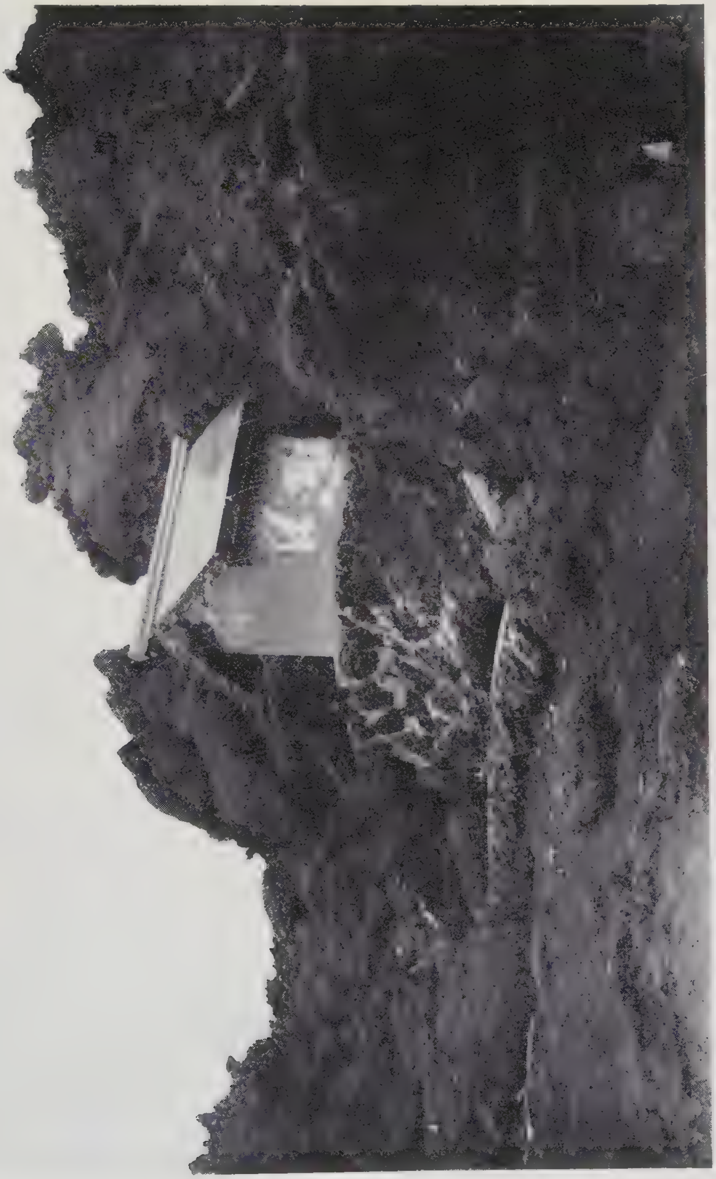

Fig. 39 - The lava stream flowed over the summit of the inner somma.
(After T. MINAKAMI)

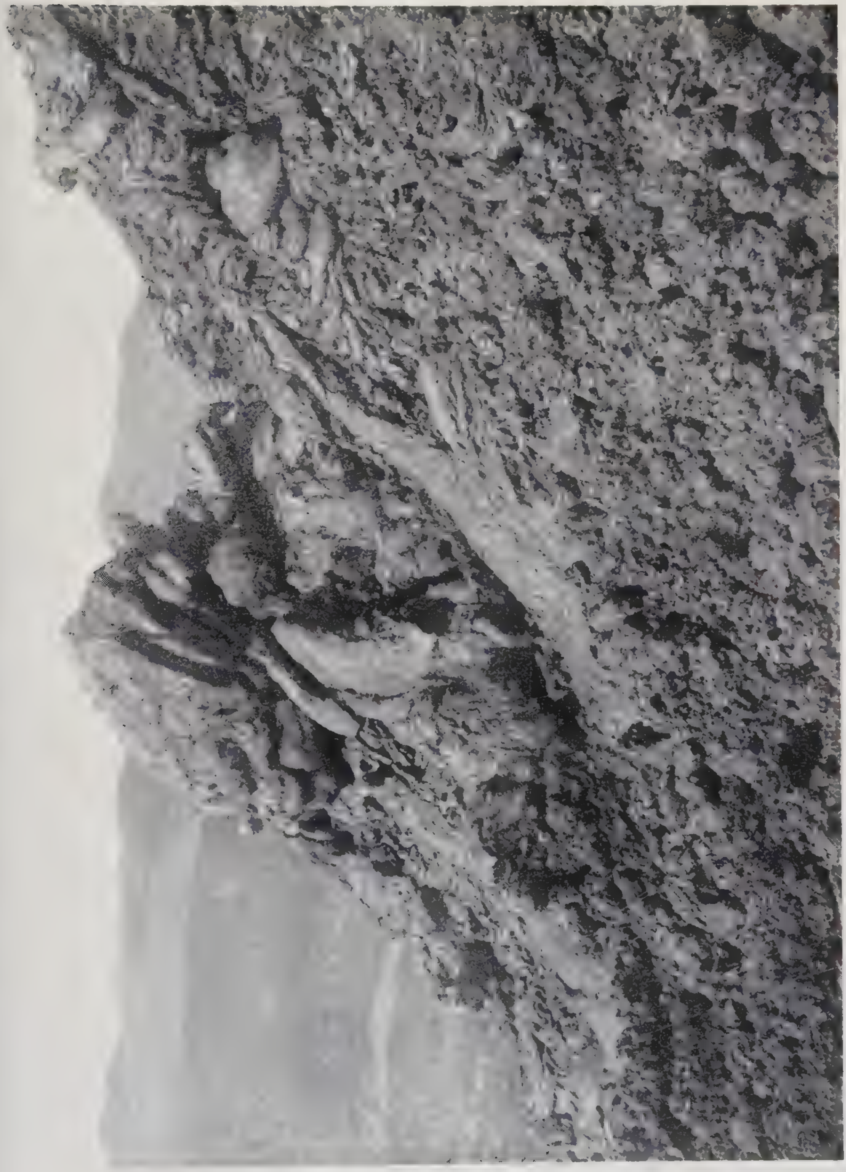

Fig. 40 - A lava stream on March 19, 1951.
(After T. Minakami)

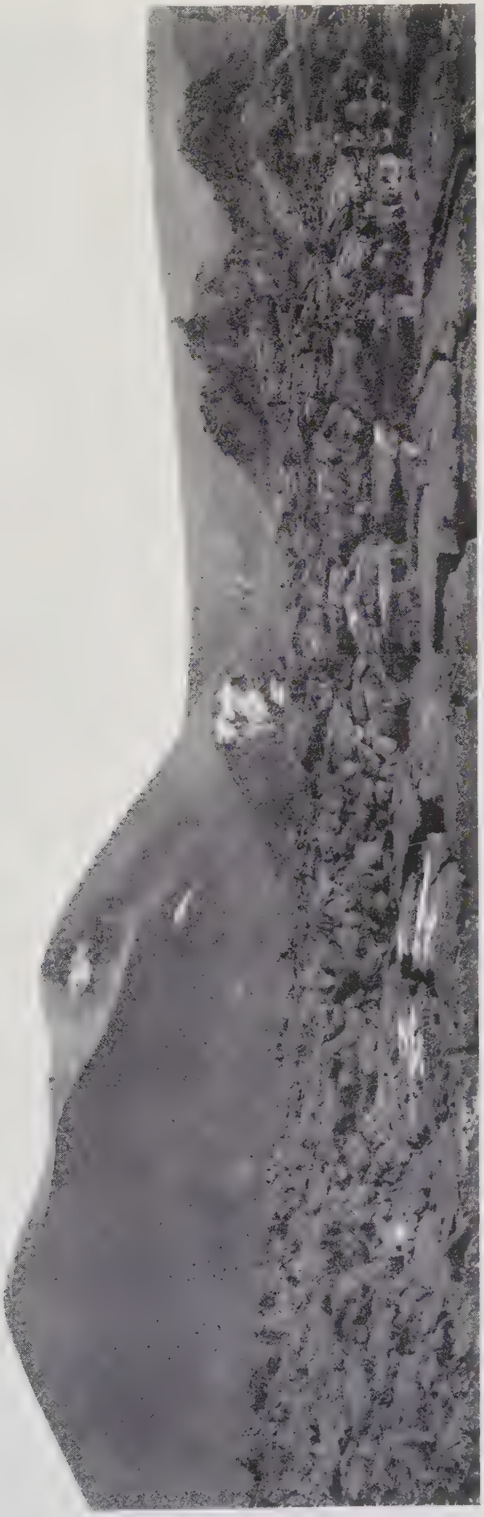

Fig. 41 - Cinder cones and driblet cones formed at the earlier stage of the 1951 eruption.
(After T. MINAKAMI)

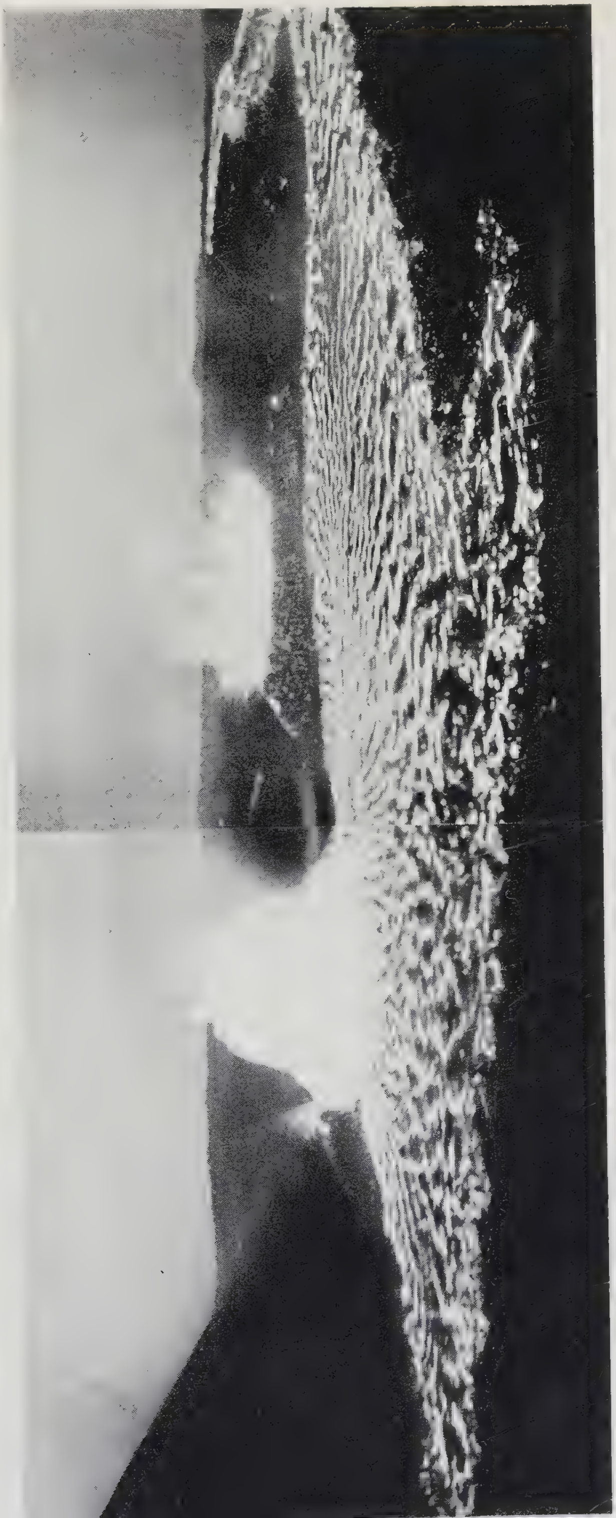

Fig. 42 - A lava fountain and the lava stream on May 7, 1951.
(After Y. TAKAGI)

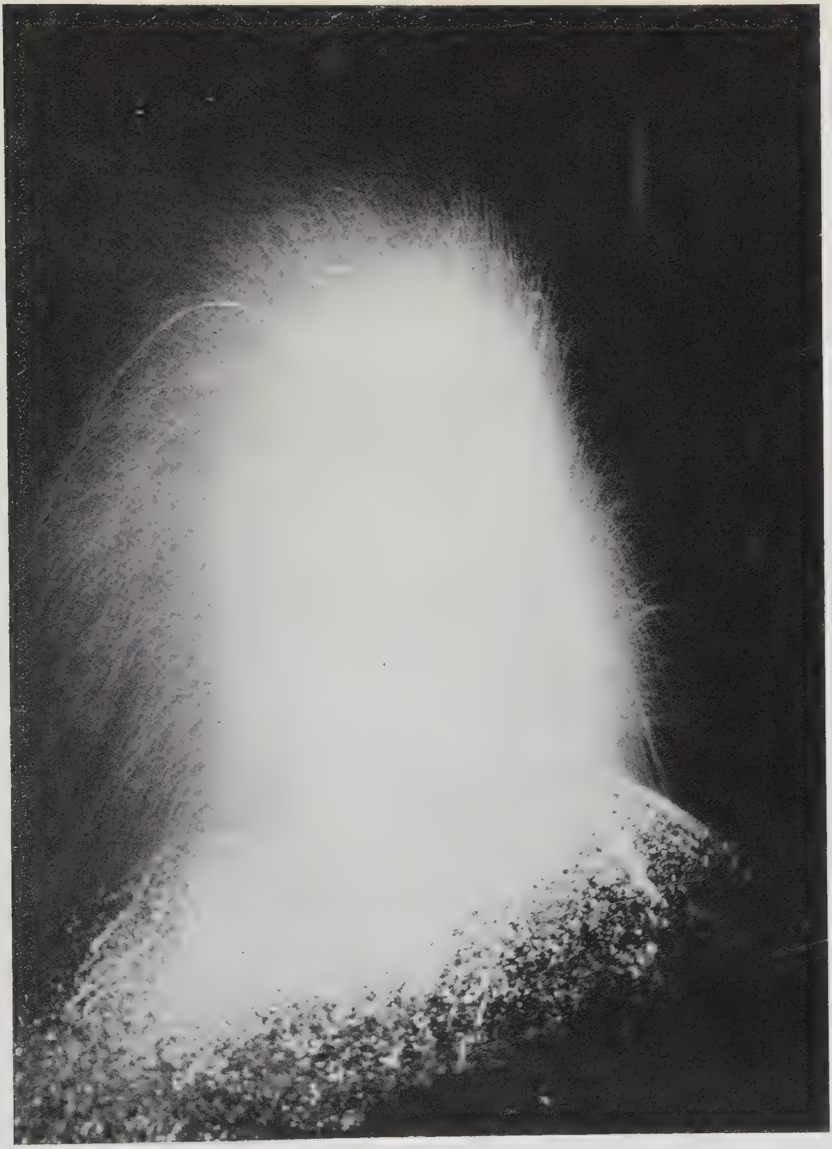

Fig. 43 - The Strombolian eruption on May 7, 1951.
(After Y. TAKAGI)

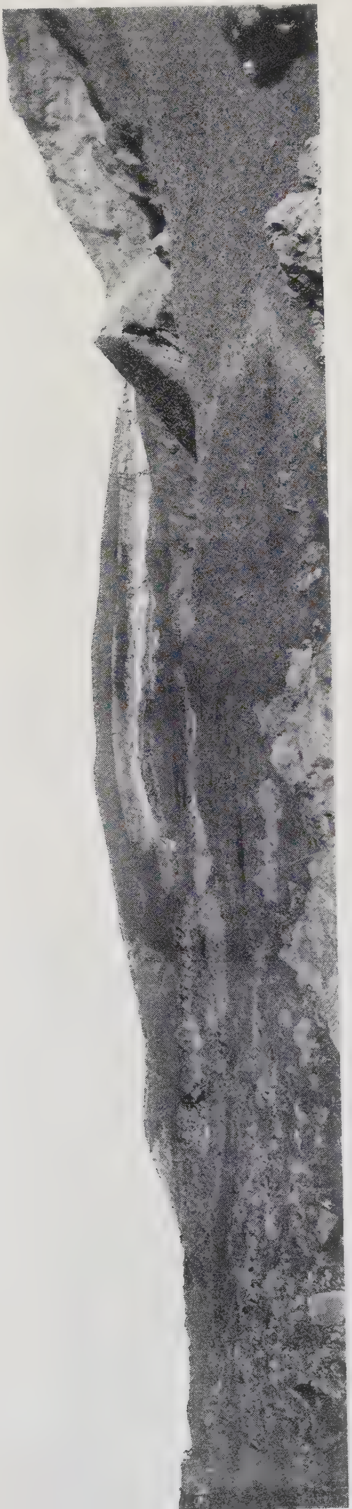

Fig. 44 - Depression inside the inner somma which occurred after the 1951 eruption.
(After T. MIYAZAKI)

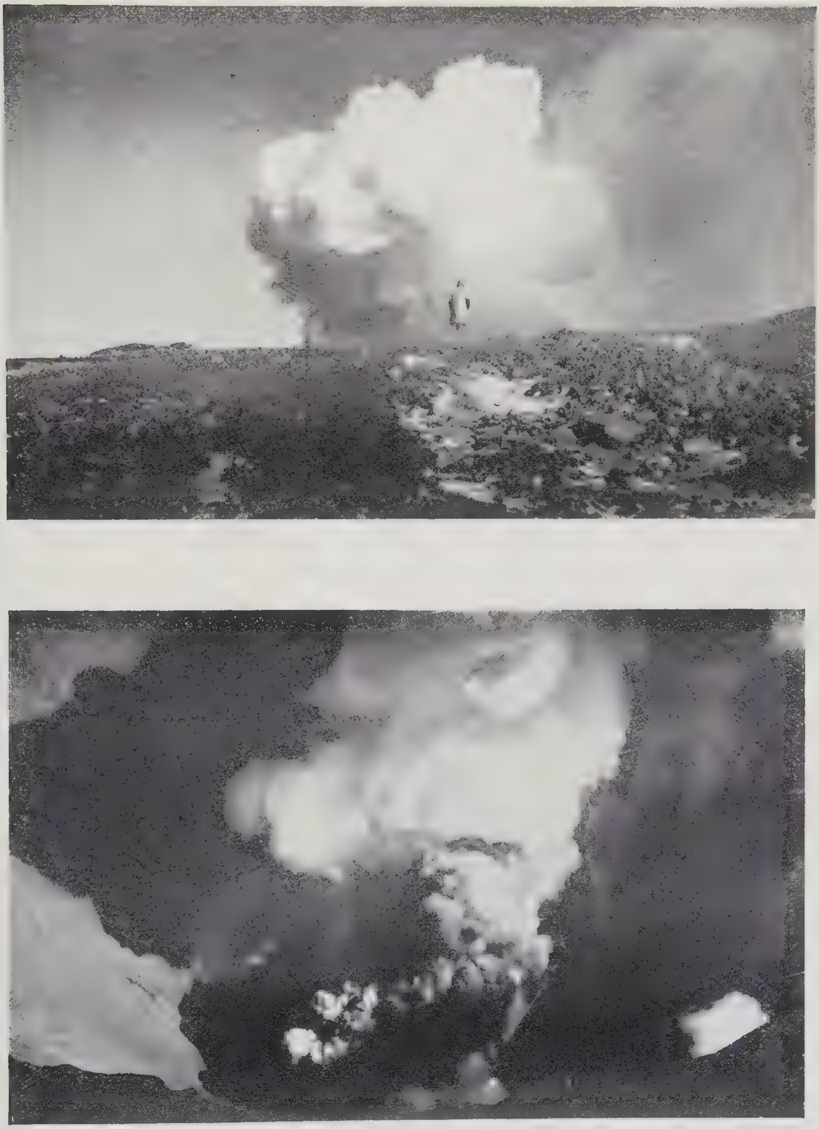

Fig. 45 - The active crater of Mt. Aso on January 6, 1950.
(After T. MINAKAMI)

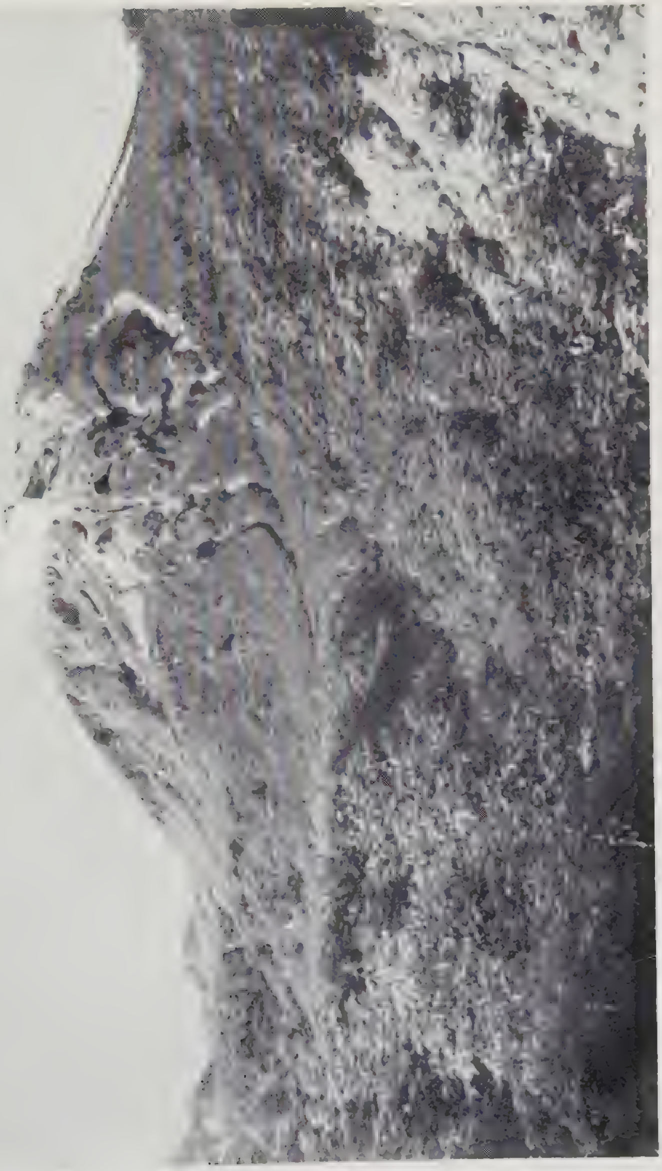

Fig. 46 - Mt. Yake-yama and the fissure newly opened.
(After T. MINAKAMI)

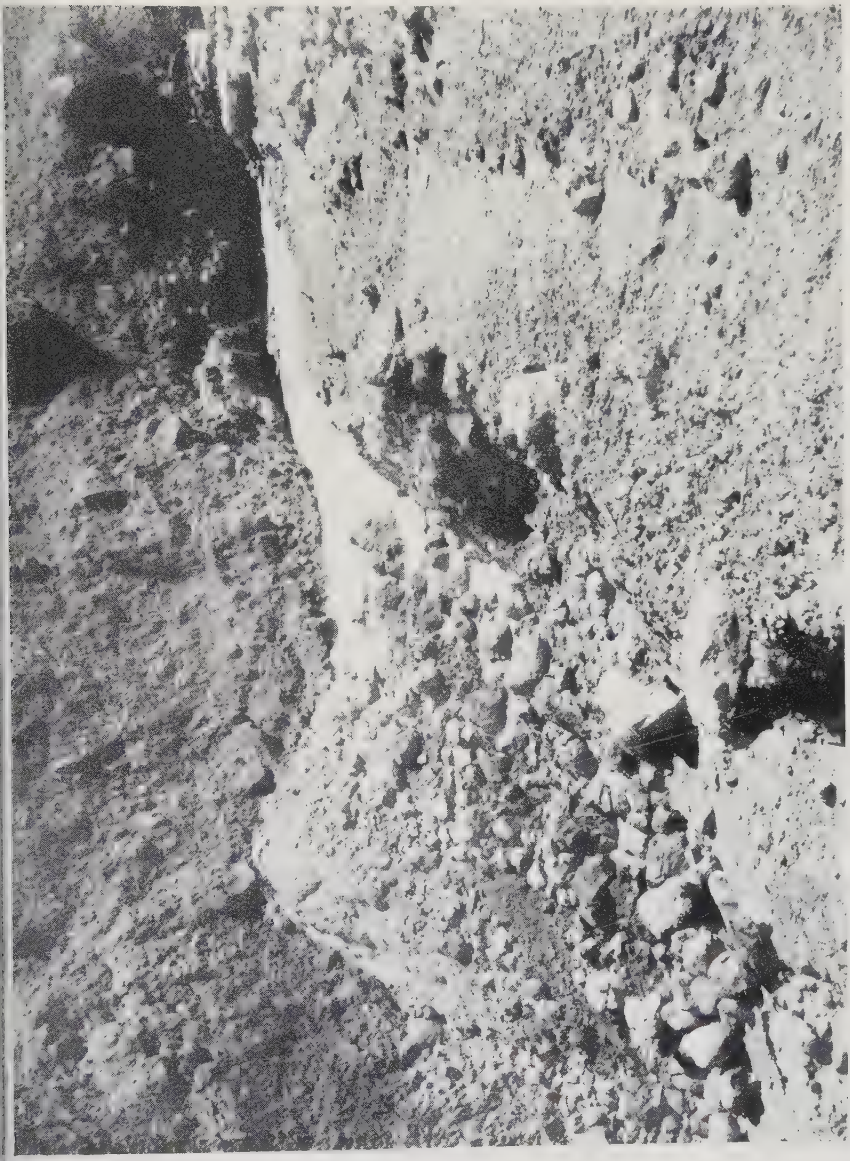

Fig. 47 - Mud and water dammed up by accumulation of ejecta and by collapse of riverside cliffs at the flank of Mt. Yake-yama (an origin of mud flow).
(After T. MINAKAMI)

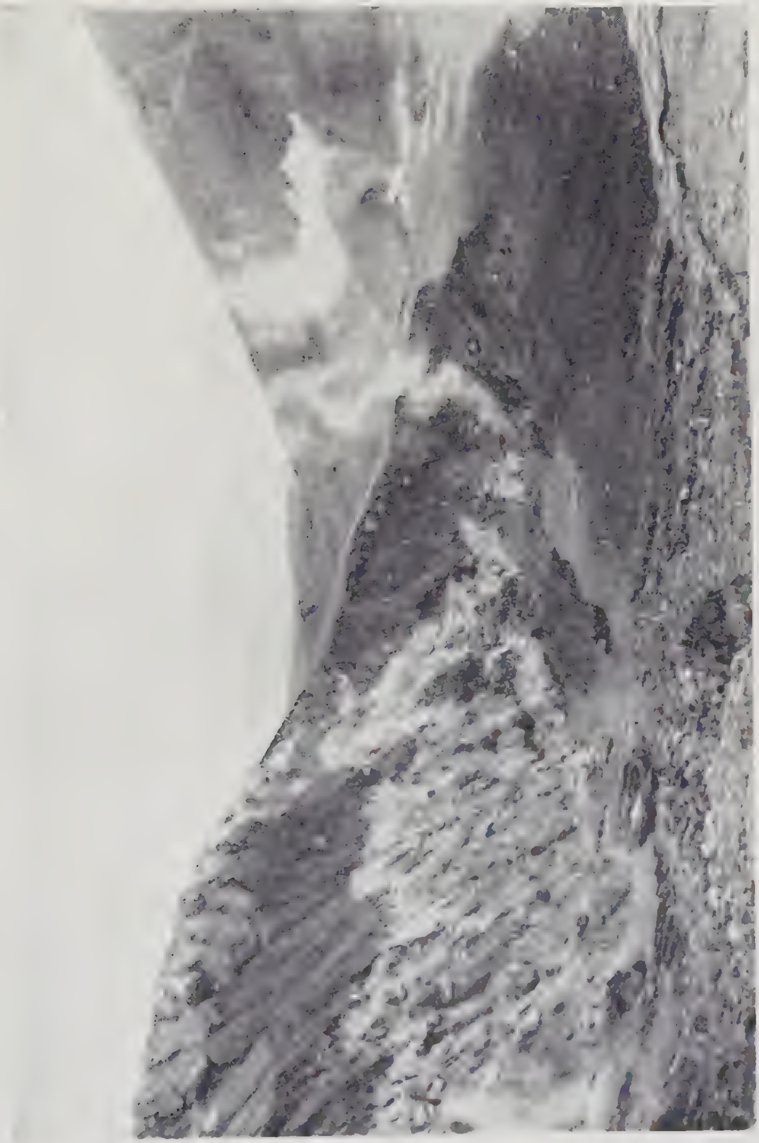

Fig. 48 - A newly formed fissure of Mt. Azuma.
(After T. MINAKAMI)

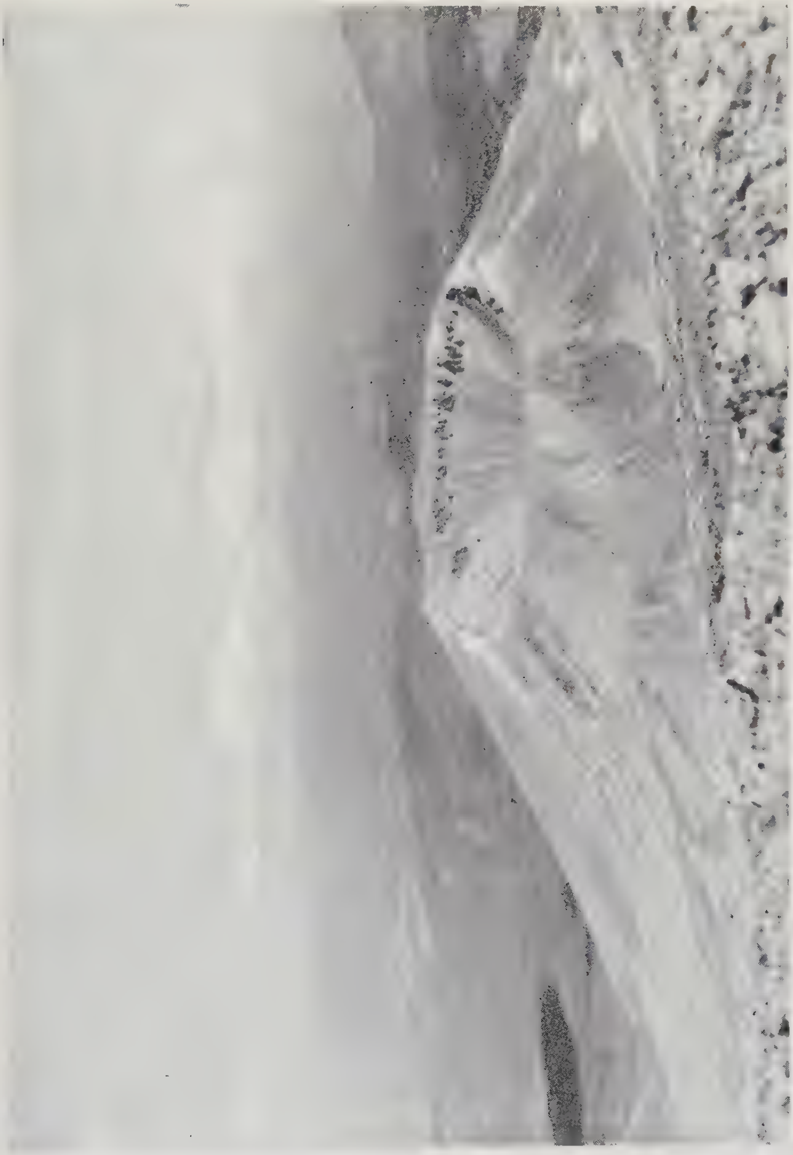

Fig. 49 - Kohuzi, a cone of Mt. Azuma.
(After T. MINAKAMI)

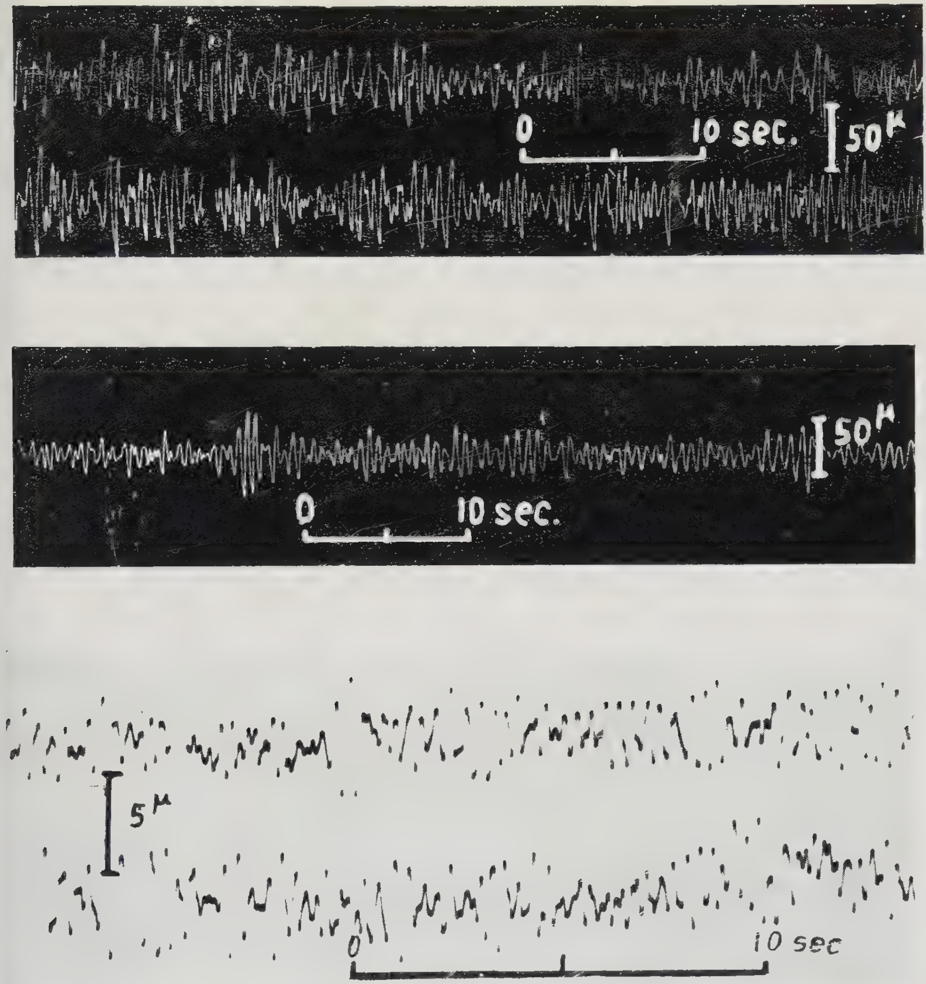

Fig. 50 - The volcanic tremors accompanied the Strombolian eruption of Oo-sima.

(1) Seismogram obtained at Δ = 0.6km (St. No. 1).
(2) Seismogram obtained at Δ = 2.0km (St. No. 2).
(3) Seismogram obtained at Δ = 4.6km (St. No. 4).

(After T. Minakami and his associates)

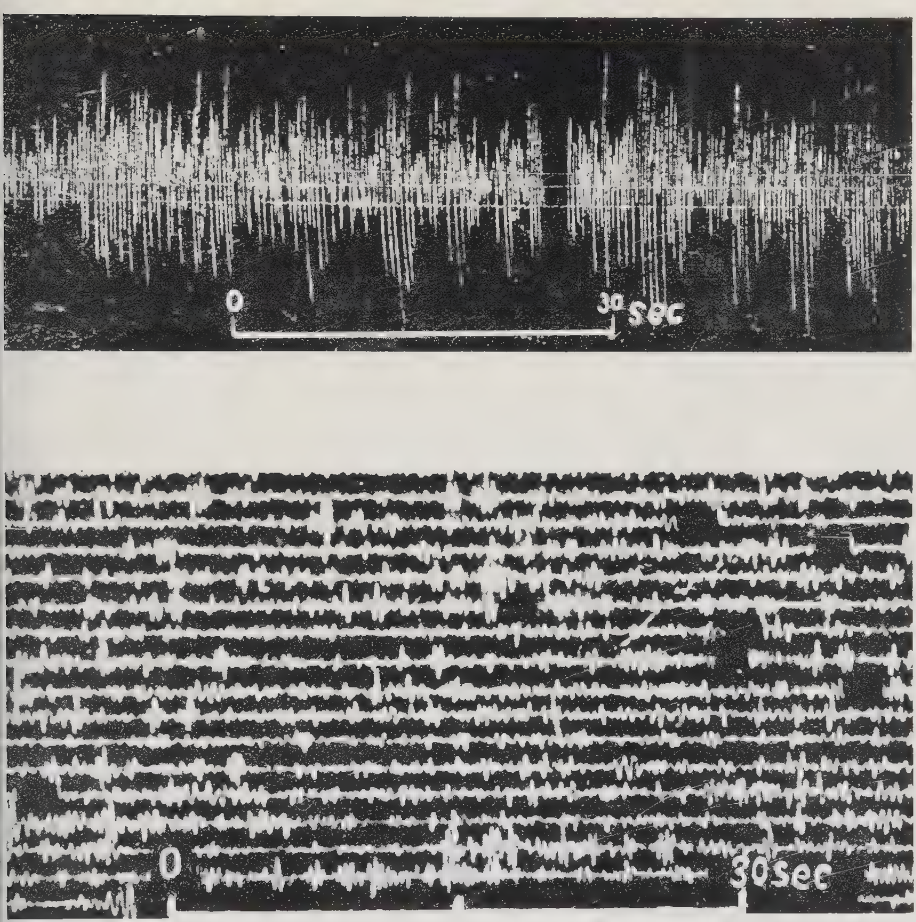

Fig. 51 — The volcanic tremors preceded to the 1949-1950 eruption of Mt. Aso.
(After T. Takeishi and T. Minakami)

FRANCESCO SIGNORE

Le ricerche vulcanologiche in Italia nel triennio 1948 - 1950

Le ricerche vulcanologiche in Italia dalla fine della seconda guerra mondiale hanno segnato una netta ripresa. A questa ripresa hanno portato il loro contributo, oltre agli Istituti scientifici: Osservatorio Vesuviano e Istituto vulcanologico Etneo, che hanno come compito specifico l'osservazione e lo studio dei fenomeni vulcanici, anche altri Istituti di scienze affini, i quali, a completamento della loro attività, si occupano anche di ricerche vulcanologiche.

In Italia vi sono anche due cattedre di vulcanologia: una presso l'Università di Catania, che, in seguito al ritiro del Prof. Ponte, per raggiunti limiti di età, fu affidata, insieme alla direzione dell'Istituto vulcanologico Etneo, al Prof. G. CUMIN per il 1949 e dal novembre 1950 al Prof. O. DE FIORE (1), e l'altra presso l'Università di Napoli, tenuta dallo scrivente.

Lo scrivente si è occupato, come per il passato, della zona vulcanica Flegrea, la quale è stata meta di continue escursioni; durante ciascun anno sono state determinate le temperature delle numerosissime fumarole e delle sorgenti termali. Dalle ricerche eseguite si è potuto dedurre che l'attività vulcanica nei Campi Flegrei non ha subito variazioni degne di nota.

Inoltre lo scrivente, come fu deciso alla VII Assemblea di Washington, 1939, ha cercato di sviluppare lo studio e la conoscenza delle sorgenti termo-minerali dell'Italia meridionale, promuovendo ricerche e prestando la sua consulenza per la soluzione di problemi tecnici e scientifici. Infine ha curato la pubblicazione del « Bulletin Volcanologique », organo dell'Association de Volcanologie de l' U.G.G.I., di cui è segretario generale.

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(1) Per la prematura morte del Prof. O. DE FIORE, avvenuta nell'aprile 1953, la cattedra di vulcanologia presso l'Università di Catania e la direzione dell'Istituto Vulcanologico Etneo sono state affidate di nuovo, all'epoca della stampa di questo Bollettino, al Prof. G. CUMIN,

Lo spazio a disposizione non permette di pubblicare per esteso le importanti relazioni pervenute dai varî Istituti; si è cercato però di riportarle integralmente nelle loro parti essenziali.

OSSERVATORIO VESUVIANO E ISTITUTO DI FISICA TERRESTRE DELL'UNIVERSITÀ DI NAPOLI

La limitazione di attività per parziali deterioramenti o distruzioni della attrezzatura in entrambi gli Istituti a causa degli eventi bellici è andata man mano riducendosi, in modo che gli osservatorî hanno potuto riprendere, specie nei settori meteorologico e sismico, l'attività normale. Anzi, con la sistemazione all'Osservatorio Vesuviano, accanto ai riattivati precedenti apparecchi: Vicentini (componenti orizzontali e verticale) ed Omori-Alfani-Malladra (sistema permettente registrazioni di componenti orizzontali e verticale), di pendoli Wiechert per le componenti orizzontali e verticale, si è avuto un miglioramento di questo ultimo servizio, reso invero indispensabile per le particolari attuali condizioni del vulcano. E' proseguita intanto l'elaborazione critica del vasto materiale raccolto nel corso del periodo eruttivo chiuso con il parossismo del marzo 1944. Diverse sono le interessanti conclusioni ottenute delle quali si dà, o si darà, notizia in pubblicazioni ufficiali dell'Osservatorio. In quanto però alle ricerche sulla pluriforme attività microsismica può dirsi che oltre ad una sempre più netta individuazione dei caratteri distintivi dei due tipi principali: armonico e spasmodico, s'è rilevato un terzo tipo, il *pseudospasmodico*, intermedio, per genesi e carattere delle registrazioni, tra l'agitazione spasmodica e quella propriamente sismica vesuviana. Difficoltà nell'interpretazione delle fasi preliminari per i sismi e particolarmente per i pseudospasmi hanno reso necessario un approfondimento delle ricerche sulla propagazione delle onde sismiche nella zona per scuotimenti superficiali o episuperficiali. In linea provvisoria sono state utilizzate registrazioni dovute agli osservatorî del napoletano, tra i quali il Vesuviano e quello di Fisica Terrestre, in relazione ad eventi bellici. Questi primi studi hanno pertanto dato la possibilità di avere un'idea delle medie caratteristiche elastiche nonchè delle potenze dei successivi strati costituenti le sottostrutture della zona flegreo-vesuviana.

Molta importanza si è inoltre data agli studi sulle variazioni nell'inclinazione del suolo all'Osservatorio, sperando di poterle al più presto estendere anche in altre stazioni da istituire lungo le pendici dell'edificio vulcanico. E pertanto oggidì con le primitive livelle della sensibilità dei $2''$ e con l'apparecchio a registrazione meccanica di sensibilità all'incirca di $0'',5$ (che ha già svelato la presenza di tipiche ondulazioni di circa $T = 110^s$) è stato, da solo qualche mese, messo in funzione un clinometro a registrazione fotografica, gentilmente concesso dall'Istituto Nazionale di Geofisica. Le indagini fin oggi effettuate, nel confermare le deduzioni esposte in occasione dell'ultima assemblea, hanno lasciato ancora mettere in risalto l'assenza nell'ultimo triennio delle anormali variazioni caratteristiche dell'attività magmatica episuperficiale o profonda.

Per integrare le deduzioni anziesposte in relazione alle vicende eruttive del vulcano sono state eseguite sporadiche ma continuative osservazioni dirette o a distanza. Tra le prime devono essere ricordate quelle sulle attività fumaroliche e termiche extracrateriche ed intracrateriche, per lo studio delle quali ultime sono state effettuate negli ultimi anni due difficoltose discese sul fondo del cratere, che, nel consentire di confermare le vedute sulla loro genesi, hanno anche potuto permettere di stabilire un legame tra i soli due gruppi di fumarole situati in prossimità del fondo craterico (di cui uno sicuramente primario e l'altro costituito da un campo solfatarico) e l'attività manifestata dal vulcano alla fine dell'eruzione. Come pure attraverso un'indagine critica delle successive manifestazioni verificatesi sui pendii meridionali esterni del Gran Cono, è stata rilevata l'esistenza di una relazione tra attuali fenomeni termici e fenomeni effusivi subterminali della primavera del 1942, in quanto entrambi dipendenti da iniezioni di masse magmatiche entro il sistema di fenditure dell'eruzione dell'aprile 1906.

L'attuale eruzione dell'Etna ha inoltre dato l'occasione per un'estensione delle ricerche già iniziate, ed eseguite anche nel corso della precedente eruzione del 1947, sulla temperatura di irrigidimento, la cui deduzione, oltre a una conferma di una netta esistenza, ne ha confermato l'alta importanza, in quanto dalla sua conoscenza è stato possibile avere una giustificazione di un apparentemente anomalo comportamento eruttivo.

Particolare attenzione è stata inoltre rivolta allo studio dei vari fenomeni geofisici comunque connessi con l'attività vulcanica. Questo gruppo di ricerche comprende: studi su fenomeni di assorbimento ed in generale ottici da parte delle polveri vulcaniche (di prossima pubblicazione); ed ancora sulla radioattività dei prodotti eruttivi; sul magnetismo delle lave. Sono state inoltre riprese misure di elettricità atmosferica, le quali, interrotte per la pressochè totale distruzione di tutta l'apparecchiatura, sono state finora svolte limitatamente a quelle relative alla variazione del campo elettrico con la costruzione di un apparecchio permettente la registrazione ad inchiostro di campi positivi e negativi.

E' stata inoltre ripresa la pubblicazione degli Annali dell'Osservatorio Vesuviano, per il momento con un volume unico (Serie V) Celebrativo del I centenario, sperando di poter poi dar corso alla pubblicazione regolare di una Serie VI, il cui primo volume è già quasi totalmente preparato.

Prof. G. IMBÒ

ISTITUTO DI VULCANOLOGIA DELL' UNIVERSITÀ DI CATANIA

Cessata, nel marzo 1949, l'eruzione laterale dell'Etna, furono continuate, da parte del personale dell'Istituto di Vulcanologia, le osservazioni e le ricerche sul vulcano, sia presso l'apparato eruttivo laterale, sia lungo la colata lavica, come al cratere centrale e a quello subterminale di N.E.

Con un contributo del Consiglio Nazionale delle Ricerche, ottenuto dall'Istituto sin dalla fine dell'eruzione laterale, fu continuato dal Prof. G. PONTE, allora Direttore dell'Istituto stesso, e dal Dr. CUCUZZA uno studio sull' andamento termico della stessa eruzione. Dalle osservazioni continuative risultarono bruschi innalzamenti di temperatura, molto probabilmente dovuti a spaccature di contrazione (sinclasi) che si andavano formando sulla massa lavica durante il consolidamento. Queste ricerche furono condotte per oltre un anno, con misurazioni di temperatura eseguite dal CUCUZZA ogni dieci giorni circa, raccogliendo di volta in volta i prodotti di sublimazione che si formavano mentre variava la temperatura. Furono condotte pure preliminari ricerche chimiche, destinate ad essere completate successivamente, allo scopo di portare un contributo allo studio della genesi dei prodotti fumarolici etnei.

Nei primi mesi del 1948 furono completate dal Prof. PONTE le relazioni, che furono poi pubblicate negli Annali dell'Istituto di Geofisica di Roma, sull'eruzione laterale dell'Etna del 30 giugno 1942, su alcune agitazioni microsismiche originate da attività vulcaniche, alla cui pubblicazione collaborarono il Prof. P. CALOI ed il compianto Prof. A. LO SURDO, e sull'eruzione dell'Etna del febbraio-marzo 1947. In questo lavoro furono inseriti tre rilievi topografici del versante Nord dell'Etna, zona del teatro eruttivo 1947, aggiornati dal Dr. CUCUZZA, in seguito alla campagna appositamente eseguita con la collaborazione del tecnico dell'Istituto, M. TAFFARA.

Dal canto suo il Dr. CUCUZZA sta elaborando la seconda parte del suo lavoro « L'eruzione dell'Etna del 1947 », nella quale saranno esposti i risultati delle ricerche sui materiali.

Mentre continuavano le osservazioni e le ricerche sul vulcano, veniva pure completato un lavoro, eseguito alla base dell'Etna, su alcune forme di fissurazione colonnare per contrazione, come risultato di un metamorfismo di contatto determinato dalle colate laviche nelle rocce sedimentarie sottostanti.

Negli Annali di Geofisica di Roma veniva intanto pubblicata dal Prof. PONTE una nota sull' attività dello Stromboli, compilata sulle informazioni pervenute all'Istituto dagli abitanti di quell'isola, alla quale pubblicazione faceva seguito una breve relazione riassuntiva sull'attività dell'Etna negli anni 1943-46.

In seguito ad alcune segnalazioni di presunte tracce di fenomeni glaciali sull'Etna, si sono iniziate delle sistematiche ricerche allo scopo di contribuire allo studio dei terreni della base dell'Etna, ove solo potrebbe eventualmente riscontrarsi una prova dell'età pliocenica del vulcano, sostenuta appunto da qualche autore.

Appena scoppiata l'eruzione laterale, il 2 dicembre 1949, il personale dell'Istituto fu subito impegnato nell'osservazione dei nuovi fenomeni, che sono stati seguiti, con tutti i mezzi a disposizione, sia presso gli apparati eruttivi dei due versanti del vulcano (giacchè l'eruzione è stata bilaterale) sia lungo le colate, come pure al cratere centrale ed a quello subterminale di N.E. Il Prof. G. CUMIN era accompagnato dall'Assistente di ruolo, Dr. CUCUZZA, dall'Ass. vol. Dr. ABBRUZZESE, dal tecnico M. TAFFARA e dai due custodi dell'Osservatorio, BARBAGALLO e CARBONARO.

Delle osservazioni eseguite durante i fenomeni eruttivi di questo periodo, sarà data relazione in prossime pubblicazioni dell'Istituto, che seguiranno quelle dello stesso Prof. CUMIN, presentate rispettivamente all'Acc. Gioenia di Catania ed alla Società Geografica Italiana.

Il Prof. DE FIORE, Direttore dell' Istituto Vulcanologico, sta provvedendo al completamento dell' attrezzatura scientifica necessaria per intraprendere nuove ricerche, sia in campagna che in laboratorio.

Dal 1948 al 1950, sono stati ospitati presso l'Osservatorio sull'Etna numerosi studiosi italiani e stranieri, che hanno eseguito varie ricerche sul vulcano, assistiti e coadiuvati dal personale. Ricordiamo fra gli altri: il Prof. M. SANTANGELO dell'Istituto Naz. di Geofisica di Roma, che, nel mese di aprile del 1949, ha visitato il cratere subterminale di N.E. prelevando campioni di scorie e di gas; il Prof. R. A. BOUTET del Centre National de la Recherche scientifique di Parigi, che, nell'agosto dello stesso 1949, ha eseguito per più giorni ricerche sull'assorbimento dell'atmosfera a varia quota; gli svedesi Proff. Olof ÄNGEBY e Sven GRUNDSTROM della Lunds Universitet geografiska institution di Lund, i quali, accompagnati dai loro due assistenti, hanno visitato, nel dicembre 1949, varie zone dell'Etna e della Sicilia, costantemente guidati ed aiutati dal personale dell'Istituto di Vulcanologia e da quello di Geografia.

In occasione della recente eruzione, iniziata nel novembre del 1950, si sono avute sull'Etna le visite dei seguenti studiosi:

Prof. G. IMBÒ, Direttore dell'Osservatorio Vesuviano, Prof. E. MEDI, Direttore dell'Istituto Nazionale di Geofisica di Roma, Dott. TAZIEFF dell'Università di Bruxelles, che venne anche in occasione dell'eruzione del 1949, Prof. RICHARD e Prof. Arne NOE-NYGAARD dell'Università di Copenaghen.

L'Istituto ha infine continuato a collaborare con l'I. N. di Geofisica di Roma, ospitando nei propri locali del Palazzo delle Scienze la stazione sismica, il cui funzionamento è affidato al personale dell'Istituto di Vulcanologia.

Presso la Casa Cantoniera dell'Etna, negli ambienti dello Istituto, è pure ospitata una stazione meteorologica dell'Aeronautica, che funziona da alcuni anni, con personale dell'Aeronautica stessa.

Dott. S. CUCUZZA SILVESTRI

ISTITUTI DI GEOLOGIA E MINERALOGIA DELL'UNIVERSITÀ DI NAPOLI

Gli Istituti di Geologia e di Mineralogia della Facoltà di Scienze dell'Università di Napoli dedicano necessariamente buona parte della loro attività scientifica allo studio sia del Vesuvio che dei Campi Flegrei, nonchè dei vulcani estinti della Penisola. In tal modo essi non solo seguono una nobile tradizione scientifica quale è quella della scuola napoletana, che può vantare uomini come Teodoro MONTICELLI, Arcangelo SCACCHI, Luigi PALMIERI, Ferruccio ZAMBONINI, Giuseppe DE LORENZO, ma obbediscono ad un preciso dovere.

Non si deve infatti dimenticare che è a Napoli (contemporaneamente a Catania) che è nata e si è sviluppata la scienza vulcanologica, e che quindi sarebbe deplorevole — e poco decoroso per la scienza napoletana — se essa venisse trascurata proprio nella città che ne è stata la culla.

Naturalmente nei suddetti Istituti si è specialmente coltivata quella parte della vulcanologia che riguarda la geologia e la mineralogia; in tali ricerche — data l'impossibilità di separare con un taglio netto le due scienze — si è sempre proceduto di conserva; si ritiene quindi inutile dare due relazioni separate.

I risultati avrebbero potuto certo essere più cospicui, se i due Istituti non avessero dovuto lottare contro la ristrettezza dei mezzi, assolutamente insufficienti, e la deficienza dell'attrezzatura scientifica, che ancora risente dei danni causati dalla guerra. Contro tali ostacoli non sempre valgono la buona volontà ed il sacrificio personale.

Le ricerche vengono divise nei tre gruppi seguenti:

a) Ricerche sul Vesuvio.
b) Ricerche sui Campi Flegrei.
c) Ricerche su altri vulcani della Penisola.

Ricerche sul Vesuvio.

Il Prof. A. SCHERILLO, continuando un suo studio sistematico sui prodotti lavici attuali del Vesuvio iniziato nel 1941, ha studiato le lave e le scorie dell'eruzione del marzo 1944, durante la quale si è avuta un'evidente differenziazione in senso melanocratico. Le analisi chimiche eseguite finora sui prodotti di questa eruzione sono 14 e sono riportate nei lavori: « *Le lave e le scorie dell'eruzione vesuviana del marzo 1944* »; « *Le ricerche petrografiche sui prodotti attuali del Vesuvio compiute nell'Istituto di Mineralogia dell'Università di Napoli* ».

E' in corso lo studio dei materiali piroclastici e dei prodotti lanciati durante l'eruzione. Alcune analisi preliminari sono riferite nel secondo dei lavori citati sopra.

Al Dott. A. LAZZARI è dovuta una nota (« *Segnalazione della caduta in Albania delle ceneri del Vesuvio dell'eruzione del marzo 1944* »), nella quale è riportata l'analisi microscopica delle ceneri vesuviane cadute nella notte fra il 22 ed il 23 marzo 1944 sul cantiere petrolifero di Devoli in Albania. Tale esame ha portato al riconoscimento di frammenti petrosi in forte percentuale, di cristalli di augite, flogopite, biotite, leucite e forse anche di oligoclasio e sanidino.

Il Prof. A. PARASCANDOLA ha reso nota la presenza, in alcuni punti delle lave del 1944, di minerali interessanti (haüyna, ecc.) e, tra i materiali piroclastici lanciati dalle ultime esplosioni, di cristalli di pirosseno di dimensioni eccezionali. Ha inoltre segnalato tra i minerali formatisi consecutivamente all'eruzione la tenorite e la cotunnite (« *I minerali del Vesuvio nella eruzione del marzo 1944 e quelli formatisi durante l'attuale periodo di riposo* »).

Il Prof. PARASCANDOLA ha proseguito inoltre le sue osservazioni sullo stato attuale del Vesuvio, sulle quali riferisce periodicamente dal 1946 alla Società dei Naturalisti (« *Notizie Vesuviane* »). Si tratta di osservazioni sulla fumarole, fenomeni termici, frane che caratterizzano l'attuale periodo di riposo del Vesuvio. Una comunicazione riassuntiva su « *Lo stato attuale del Vesuvio* » è stata letta dal Prof. PARASCANDOLA al Congresso della Società Geologica di Roma.

Ricerche sui Campi Flegrei.

Notizie preliminari *sui recenti scavi nelle colline a nord di Napoli* furono comunicate nell'adunanza del 29 dicembre 1948 alla Società dei Naturalisti da G. D'ERASMO e A. SCHERILLO. Esse riguardano la grande arteria sotterranea che la Società per l'Acquedotto di Napoli ha cominciato a scavare nella zona collinosa e settentrionale della città che va dal bosco di Capodimonte, attraverso i valloni delle Fontanelle, dei Gerolomini, di Montedonzelli ecc. fino a S. Stefano al Vomero Vecchio.

Ulteriori dati su alcune particolari varietà di tufi incontrate in tali scavi ha fornito il Prof. SCHERILLO in un lavoro (« *Petrografia chimica dei tufi flegrei: I. Il tufo giallo* »), corredato di 14 nuove analisi chimiche, che vorrebbe essere il primo di una serie diretta a illustrare i vari tufi flegrei dal punto di vista chimico-petrografico. In questo vengono studiati i tufi gialli e grigi del secondo periodo flegreo di S. Stefano al Vomero, e i tufi gialli di Mergellina, M. Gauro e dello scoglio del Lazzaretto, e alcune pomici e scorie incluse.

A molte ricerche sui Campi Flegrei ha atteso e attende il Prof. PARASCANDOLA. Tralasciando necessariamente, perchè pubblicate nel 1947, la monografia sul Monte Nuovo e il Lago Lucrino e quella sul Serapeo di Pozzuoli, è da ricordare la descrizione di alcuni minerali della zona flegrea: realgar della Solfatara (al cui studio cristallografico attende il Dott. R. SINNO), breislakite del tufo campano, melilite di un incluso della trachite di Astroni e in particolare di alcuni minerali della regione

Pisciarelli, tra i quali la pirite, l'alotrichite, la voltaite e la pickeringite (di cui è stata eseguita l'analisi), che si può considerare segnalata per la prima volta in Italia (« *Contributo alla mineralogia flegrea* »).

Non va infine passato sotto silenzio che il Prof. PARASCANDOLA attende da anni ad un lavoro monografico sull'Isola di Procida, che si spera possa essere completato tra breve, nonchè su qualche località flegrea di particolare interesse.

In una nota su « *La terrazza della Starza nei Campi Flegrei* », il Dr. V. MINIERI descrive dal punto di vista morfologico, stratigrafico, paleontologico e genetico la terrazza marina della Starza che si estende lungo il litorale flegreo dalla località Gerolomini presso Pozzuoli fino alla collina di Tritoli e che si è costituita essenzialmente col disfacimento dei tufi trachitici del vicino vulcano del Gauro e col successivo accumularsi di quei materiali in ambiente litorale, come è chiaramente mostrato dai caratteri dello strato fossilifero inglobatovi, ricco di numerose specie di foraminiferi, celenterati e molluschi, tuttora viventi.

Un lavoro di argomento flegreo può pure essere considerata la nota della Dott. M. ZEI sui « *Nuovi pozzi trivellati per l'alimentazione di Napoli* », in cui sono stati passati in rassegna i diversi materiali piroclastici e lavici incontrati nello scavo di 22 pozzi trivellati, negli anni 1945 e 1946, nella zona a nord est della città di Napoli per ricerche di acqua potabile. La maggior parte dei depositi inferiori si è infatti rivelata di origine sicuramente flegrea, mentre superiormente si sono incontrati prodotti vesuviani (per lo più tufi grigi incoerenti).

Ricerche su altri vulcani.

Il Prof. SCHERILLO ha pubblicato un lavoro conclusivo dei suoi studi petrografici sui Vulcani Sabatini, a nord di Roma, iniziati nel 1933 (« *La differenziazione nei Vulcani Sabatini-Lazio* »). In questo lavoro si traccia il diagramma di consolidazione magmatica e si discutono le possibili cause di questa.

Il Prof. SCHERILLO collabora ora coll'Istituto di Mineralogia dell'Università di Roma, nello studio del Vulcano Laziale.

Prof. G. D'ERASMO - Prof. A. SCHERILLO

ISTITUTO DI GEOLOGIA APPLICATA DELL'UNIVERSITÀ DI NAPOLI

Compatibilmente con la propria attività precipuamente rivolta allo studio di problemi di geologia tecnica, questo Istituto, seguendo una tradizione che rimonta ormai a molti anni, ha continuato ad interessarsi di studi vulcanologici volti specialmente alla conoscenza dei problemi concernenti la petrografia delle rocce vulcaniche. Ciò tanto più che presso questo Istituto è stato ospite ed ha svolto la sua attività, come direttore del Centro geominerario dell'I.R.I. prima e del Centro Studi Silani del C.N.R. poi, il Prof. A. RITTMANN, cui tanto devono gli studi vulcanologici del bacino del Mediterraneo.

Nel 1948, nel Bollettino Svizzero di Mineralogia e Petrografia A. RITTMANN pubblicava un'importante memoria dal titolo « *Origine e differenziazione del magma ischitano* », ribadendo il proprio punto di vista sulla natura del magma originario sottocrostale e giungendo alla conclusione che i magma capostipiti locali dei bacini campani sono a loro volta differenziati sialici del magma originario oceanico basaltico introdottosi nelle fratture abissali collegabili all'abbassamento della Tirrenide. Le differenze che si possono riscontrare tra essi e i differenziati sialici ben noti delle Isole del Pacifico si spiegano in primo luogo in base alla modalità dell'intrusione ed in secondo luogo agli effetti dell'assimilazione di sostanze sedimentarie. Nel caso del magma ischitano si è trovato altresì che la differenziazione pneumatolitica è della massima importanza tanto da superare di gran lunga, per i fenomeni che avvengono nelle parti alte del bacino, quella della differenziazione gravitativa di cristalli.

Inoltre il Prof. RITTMANN, in collaborazione con il Prof. IPPOLITO, ha pubblicato una memoria sulla stratigrafia del Somma Vesuvio, nella quale, sulla base dei suoi precedenti lavori, ha esaminato e descritto la stratigrafia di questo vulcano e specialmente ha discusso il problema dell'origine dei tufi grigi campani, ribadendo la vecchia idea dello SCACCHI sull'esistenza di molti vulcani di tufo grigio campano e non di un unico grande.

In occasione del bicentenario dell'inizio degli scavi di Pompei, l'Istituto di Geologia applicata è stato incaricato dal Prof.

MAIURI, Sopraintendente alle Antichità della Campania, di collaborare alla raccolta di studi pubblicati in tale occasione. Frutto di questo rinnovato interesse per le vicende del Somma Vesuvio sono stati quattro lavori e precisamente. Una memoria del Prof. RITTMANN dal titolo « *L'eruzione vesuviana del 79 - studio magmalogico e vulcanologico* », nella quale l'Autore ha esaminato, sulla base dei documenti che la natura stessa offre, e cioè sulla base dei prodotti dell'eruzione, il meccanismo di essa, ricostruendone lo andamento e svolgendo delle interessanti considerazioni sulla controversa questione della forma dell'edificio vulcanico vesuviano prima dell'eruzione del 79. Il Prof. IPPOLITO si è invece occupato del seppellimento di Pompei ed Ercolano, riprendendo in esame la famosa polemica sull'argomento e ribadendo, alla luce di nuove osservazioni petrografiche, il concetto che il seppellimento di Ercolano fu dovuto a colate di fango. L'Ing. P. NICOTERA, Aiuto presso l'Istituto, ha invece eseguito uno studio petrografico dettagliato sulle rocce laviche adoperate nell'antica Pompei; egli ha preso in esame la trachite del Tempio di Venere e dal paragone con altre trachiti della zona ha potuto stabilire che con ogni probabilità questa trachite proviene dall'Isola di Ischia e precisamente dalla colata lavica di Zara; ha poi studiato la lava della pavimentazione stradale di Pompei stabilendo che essa appartiene ad una potente colata lavica del III periodo dell'attività eruttiva del Somma Recente, emessa in una delle ultime eruzioni di questo periodo, all'incirca nell'VIII sec. A. C.; infine ha preso in esame la roccia lavica adoperata nelle *macine*, stabilendo che con ogni probabilità queste lave sono state prelevate nella regione del vulcano di Roccamonfina.

La Dott. A. PESCIONE infine ha preso in esame gli altri materiali da costruzione adoperati nell'antica Pompei, e precisamente il tufo grigio pipernoide di Nocera, il travertino di Serino, varie lave ottavianitiche e scorie vulcaniche ed infine il calcare del Foro.

Un'altra parte dell'attività dell'Istituto è stata dedicata agli studi sulla costituzione del sottosuolo di Napoli. Sono questi, studi di petrografia applicata o di geologia tecnica che hanno particolare importanza in campo vulcanologico, in quanto trattano quasi sempre di materiali vulcanici o di morfologia vulcanica. A quest'ordine di ricerche appartiene un'interessante nota dell'Ing. NICOTERA su un tufo trachitico, particolarmente duro, della collina del Vomero, che è stato studiato dal punto di vista petrografico e dal punto di vista meccanico, confrontando i risultati con quelli di altre varietà di tufi. Inoltre il Prof. IPPOLITO, in collaborazione con l'Ing. V. COTECCHIA, ha preso in esame i campioni provenienti da alcuni pozzi trivellati nella zona industriale di Napoli. Tale studio ha permesso di confermare l'esistenza nella zona industriale di Napoli di due falde artesiane scorrenti nei materiali piroclastici della zona ed ha rilevato l'esistenza di una colata lavica scoriacea che può definirsi come un'ottavianite nel sottosuolo di quella zona.

L'Istituto di Geologia applicata di Napoli, inoltre, sia tramite l'Ing. VIGHI, professore incaricato di Arte Mineraria, sia tramite il proprio aiuto Ing. P. NICOTERA, ha collaborato ad un nuovo rilevamento geologico dettagliato, alla scala 1/25.000 dei Campi Flegrei; rilevamento eseguito, per incarico della S. A. Forze Endogene Napoletane (S.A.F.E.N.) sotto la direzione del Prof. A. RITTMANN, dai due citati studiosi e dai Proff. F. FALINI e U. VENTRIGLIA dell'Istituto di Giacimenti Minerari della Università di Roma. Tale rilevamento, che ha messo capo alla pubblicazione di una carta dettagliata al 25.000, accompagnata da una cartina vulcano-tettonica, illustrata da 5 note e da una sintesi del Prof. RITTMANN, è attualmente in corso di stampa nel Bollettino della Società Geologica Italiana e sarà pubblicato nel corso di quest'anno.

Prof. F. IPPOLITO

Hanno infine portato dei contributi, in modo più o meno diretto, al progresso degli studi vulcanologici i vari centri di studio del Consiglio Nazionale delle Ricerche per la geologia, la mineralogia, la geochimica, la geografia fisica, la geografia, la geologia applicata, l'Istituto geologico italiano e le Scuole di perfezionamento in Idrologia, crenologia e talassologia, che sono state da alcuni anni istituite presso le facoltà di Medicina delle varie Università.

La loro attività scientifica è riportata principalmente nelle riviste « La Ricerca Scientifica » del C. N. R. e « La Clinica Termale » Roma, per gli anni 1948-1950.

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Bruxelles, Agosto 1951.

GUSTAV HANTKE

Übersicht über die vulkanische Tätigkeit 1948-1950

(Mit 1 Abbildung)

Während der Jahre 1948 bis 1950 war die vulkanische Tätigkeit von wechselnder Stärke. Nachdem 1946 40 und 1947 43 Vulkane in eruptiver Tätigkeit waren, ging ihre Zahl im Zeitraum des Jahres 1948 auf 33 zurück. Die grössten Ausbrüche 1948 waren am Schiwelutsch auf Kamtschatka (Quellkuppenbildung, 100 Mill. m^3 Lava), Lama Heroe auf Lomblen (Quellkuppenbildung) und Nyamlagira in Zentralafrika (neuer Satellit); Stärke und Förderung des Villarica-Ausbruchs in Chile waren nicht gross, aber die Verheerungen durch Schneeschmelzwasser bedeutend. Mehr als ein Drittel der 1948 tätigen Vulkane förderte Lava.

1949 stieg die Anzahl der eruptiv tätigen Vulkane auf 40, davon waren nur 13 effusiv tätig und fanden nur zwei heftige Ausbrüche statt: auf den Inseln La Palma (Atlantic) und Roeang (Indonesien); Förderungsangaben liegen vor für den Mauna Loa-Ausbruch (70 Mill. m^3 Lava) und für den Ätna-Ausbruch (11 Mill. m^3 Lava). In den Neuen Hebriden entstand eine Vulkaninsel.

1950 waren 28 Vulkane tätig (Liste noch nicht vollständig !), davon 10 effusiv, die Anzahl starker Ausbrüche nahm zu: im Juni förderte der Mauna Loa 500 Mill. m^3 Lava, der Ätna im November und Dezember 120 Mill. m^3 Lava, weitere starke Ausbrüche am Asama und Mihara in Japan und auf der Philippineninsel Camiguin.

Mehrfach wurden durch plötzliche Explosivausbrüche Umwohner und Bergsteiger getötet: 1948 und 1950 auf der Insel

Camiguin 5 bzw. 66, 1949 am Purace 17 und 1948 am Villarica 40.

In der folgenden Übersicht kann ich auch Ergänzungen zu meinem letzten Bericht (s. Lit. 15) bringen, insbesondere für die Aleuten, Kamtschatka und Indonesien.

AMERIKA

Sitkin

Der Vulkan der Insel Sitkin (1750 m nach COATS, s. 10) in den westlichen Aleuten ist nach der Lavadombildung 1945 in erhöhter Tätigkeit geblieben. Am 30 Dezember *1949* und am 7. Januar *1950* beobachtete A. E. JONES von der Insel Adakh aus leichte Aschenausbrüche und vom 5. bis 29. November 1950 folgte eine Serie starker Aschenexplosionen mit elektrischen Entladungen, deren eine allein 20000 m^3 Asche förderte (53).

Akutan

Die Vulkaninsel Akutan (1293 m nach COATS, s. 10) in den östlichen Aleuten gipfelt in einer Caldera von 2000 m Durchmesser, deren Zentralkegel zu den tätigsten Vulkanen des Aleutenbogens gehört. Die Ausbrüche sind vorherrschend explosiv, jedoch auch Lavaergüsse häufig, zuletzt im Dezember 1946 und Januar 1947; *1948* war Akutan leicht explosiv tätig (10).

Schischaldin

Der höchste und sehr häufig tätige Vulkan Schischaldin (Agajedan, Sissagjuk, 2858 m nach COATS, s. 10) auf der Aleuteninsel Unimak war nach stärkeren Aschenausbrüchen im August, September, Dezember 1946 und Januar 1947 während des Jahres *1948* nur leicht explosiv tätig (10).

Pawlof

Der Doppelkegel des Pawlof ist der am häufigsten tätige Vulkan im östlichen Teil der Aleuten-Alaska-Reihe. Von 1762 bis 1786 war noch der nördliche Kegel tätig (Pawlof Sister bei COATS, s. 10, 2135 m), dessen Krater dann durch eine Quellkuppe verschlossen wurde und seitdem erfolgen die Ausbrüche aus dem 2715 m hohen Südkegel. Beide Vulkanberge haben eine sehr regelmässige Form und sind von älteren Bauten umgeben, ihre Produkte sind andesitisch. Ausbrüche des Südkegels: 1790, 1825, 1838, 1844, 1846 (Lava), 1852, 1866 (starke Explosion), 1880, 1886, 1892, 1894, 1906-1910, 1911 (Lava), 1914 (starke Explosion), 1917, 1922-25, 1929, 1931, 1936, 1937 (im Juli mehrere starke Aschenfälle über die Halbinsel Alaska), 1942-1945, 1947 (Rauchemission).

Im Mai *1948* Explosivtätigkeit und wahrscheinlich auch Lavaerguss (10) und am 31. Juli *1950* plötzlicher starker Explosivausbruch des Pawlof, in der folgenden Nacht war die Glutlohe des Vulkans 1000 m hoch. Im Laufe des Monats August leichte und im November starke Explosivtätigkeit des Südkegels (53, 55).

Paricutin

Der am 20. Februar 1943 entstandene Paricutin in Mexico (s. 15, p. 166-170) ist 1948-1950 weiter tätig geblieben, wenn auch mit abnehmender Intensität. Während in den Jahren 1943 bis 1947 zwei Lavaquellen im SW und NO abwechselnd tätig waren, erfolgte der Lavaerguss nachdem nur an der NO-Seite. Hier entstand am 18. Februar *1948* eine neue Bocca, Nuevo Juatito genannt, etwa an der gleichen Stelle, wo der nun völlig unter den Lavamassen verschwundene Satellit Zapicho lag. Während die Lavaförderung des Vulkans ziemlich gleichmässig blieb, nahm die Explosivtätigkeit gegen Ende des Jahres 1948 ab.

Am 26. und 27. November *1949* hat Prof. TERMER den Paricutin besucht und während anhaltender Tätigkeit bestiegen. Die sich fast ununterbrochen folgenden Explosionen förderten wenig Asche, aber reichlich Lapilli, Bomben und Schlacken, die Dampfmassen bildeten grosse, gelbliche Kumuluswolken. Die meisten Bomben hatten eine glatte Oberfläche, Brotkrustenbomben waren selten. Die höchste Stelle des Kraterrandes im NW erreicht 2790 m abs. Höhe (am 19. Dezember 1944: 2680 m), aber über die den Kegel auf allen Seiten umgebenden Lavafelder erhebt sich der Aschenkegel nur 300 m. Der Krater war zur Zeit von leicht elliptischer Form, 300 m breit und etwa 50-60 m tief. Den Kraterboden bildete eine rotbraune Lavafläche mit einzelnen grünlichen Sublimationsflecken. In dieser Lava lagen zwei tätige Bocchen, die grössere im NW war ein rechteckiger Schacht, 20 × 10 m gross, die kleinere im SO war rund. Die NW-Bocca war die weitaus stärker tätige und leuchtete ihr Schacht in heller Weissglut. Ihre Explosionen folgten sich alle 2-8 Minuten, sie begannen mit dumpfem Brausen, dann stiegen mit lautem Knall blaurote Stichflammen hoch empor und dann erschien mit lautem Poltern eine gelbe Dampfwolke. Die festen Auswurfsmassen waren rotglühende Schweisschlacken und Bomben, die bis zu 600 m über den Kraterrand flogen. Sie fielen meist in den Krater zurück und viele der noch in weichem Zustand ausgeworfenen Schlacken erlitten während des Fluges Formveränderungen. Die kleinere südöstliche Bocca trat während der 1 ½ Stunden, die Prof. TERMER am Kraterrand weilte, nur dreimal in Tätigkeit. Aus ihr leuchtete eine dunkelrote Glut, ihre Ausbrüche waren ähnlich denen der NW-Bocca und ebenfalls von Flammen begleitet, aber weniger stark. Anscheinend arbeiteten die beiden Bocchen unabhängig voneinander. Der Lavaerguss erfolgte immer noch aus der Bocca Nuevo Juatito und schon nach kurzem Lauf hatte der Strom eine Breite von 80 m. Er hat hohe Seitenwälle und fliesst erst über die Taquilava von 1944 nach NO und O und biegt dann über dem verschütteten Ort Parangaricutiro nach NW und W um. Abstürze erkaltender Blöcke von den Steilwänden des Stroms bildeten grosse Staubwolken, des Nachts leuchtet die Lava nahe der Quelle in starker Rotglut, bis sich dann im Unterlauf nur noch wenige Glutpunkte in der am Tage rostroten Kruste zeigen.

Auch F. H. POUGH fand bei seinem Besuch des Paricutin am 20. Februar *1950*, dass die Tätigkeit des Vulkans in den letzten zwei Jahren stark nachgelassen hatte. Die Niederung, in welcher sich der Vulkan vor sieben Jahren gebildet hatte, war nun völlig mit seinen Lavamassen ausgefüllt und aus diesem Lavafeld ragte der Kegel nur wenig hervor. Die Lava floss immer noch aus der Bocca Nuevo Juatito im NO und bewegte sich mit nur geringer Geschwindigkeit nach N hin, die Stirn rückte in drei Tagen nur 1 m vor. An der Lavaquelle war in der Nacht noch Glut sichtbar, hier auch Dampfemission mit rollendem Getöse und oft Auswurf von Lavafetzen. Die jetzt fliessende Lava war zähflüssiger als früher, die Stromstirn 30 m hoch und sehr steil, eine kleinere Zunge bewegte sich über ältere Lava nach W hin. Auf dem 1944 geflossenen Taquistrom waren sekundäre Strömchen ausgebrochen. Die Explosionen des Gipfelkraters waren 1950 seltener und schwächer als 1948 und 1949 und förderten meist nur eine geringe Anzahl Bomben, die meist wieder in den Krater zurückfielen. Zeitweise war die Dampfsäule des Kraters verschwunden, die sonst 1000 m hoch stieg. Die meisten Bomben waren beim Auswurf schon fest, wenn auch noch glühend, selten wurden sie in halbflüssigem Zustand ausgeworfen. Bei zeitweiliger Tätigkeitsverstärkung fielen sie bis 1500 m weit und zerbrachen oft beim Fall (36, 37, 43, 51).

Abb. 1 zeigt den Paricutin im Aschenausbruch zur Zeit seiner stärksten Paroxysmen im Mai 1944. Die Form des Kegels hat seitdem von ihrer Regelmässigkeit nichts eingebüsst, aber der Kegelfuss ist überall unter den jungen Lavamassen verschwunden.

Tacana

Das NW-Ende der Vulkanreihe von Guatemala bildet der 4064 m hohe Tacana, dessen Gipfelkrater von einer 190 m hohen Quellkuppe aus Hornblende-Hypersthen-Andesit ausgefüllt ist. 1855 entstand ein Flankenkrater an der SW-Seite, der auch 1878 und 1902 tätig war. Am 1. Januar *1950* ist der Tacana wieder in Tätigkeit getreten: Explosionen, Rauchwolken, Flucht der Umwohner (4, 55).

Santa Maria

Die seit 1922 wachsende 600 m hohe Quellkuppe Santiaguito im südwestlichen Hangkrater des Santa Maria (3768 m) in Guatemala (s. 15, p. 170) ist auch *1948-50* tätig geblieben und hat sich weiter vergrössert (2).

Fuego

Im November *1949* hatte der Fuego (3835 m) in Guatemala, zuletzt 1947 tätig, wieder einen kleinen Aschenausbruch und war auch sonst stets kräftig dampfend (4, 55).

Izalco

Die Tätigkeit des Izalco (1885 m) in El Salvador hatte Ende *1947* stark nachgelassen und war der Vulkan im Februar *1948* fast ganz still geworden. Erst am 4. November '48 begann wieder eine Periode stärkerer Explosivausbrüche unter leichten Beben. *1949* war der Vulkan nur schwach tätig und war dann im Mai und Juni *1950* wieder völlig ruhig. Am 7. Juli folgte auf diese kurze Ruhe ein starker Explosiv- und Effusivausbruch: hohe, gluterleuchtete Rauchsäule, Lavaströme an den Flanken, die Knalle der Explosionen waren weithin hörbar (3, 4).

Cerro Negro

Der Cerro Negro am Las Pilas (1071 m) in Nicaragua ist nach seinen letzten Ausbruch im Juli 1947 (s. 15, p. 171) nur kurze Zeit ruhig geblieben: Am 21. November *1950* begann ein neuer starker Explosivausbruch mit hohen Rauchsäulen, Aschen- und Sandauswurf und Getöse. Am 29. November noch anhaltende Tätigkeit mit gluterleuchteten Rauchsäulen, Begleitbeben und Aschenfall bis Leon. Auch vom 17. Dezember werden Explosivausbrüche berichtet, dichter Aschenregen über die Stadt Leon (2, 3).

Masaya

Der Krater Santiago des Masaya-Vulkans (660 m) in Nicaragua stösst seit *1946* fortwährend reichlich Schwefelgase aus, welche besonders die Landwirtschaft in der Sierra de Managua schwer schädigen. Diese Tätigkeit des Vulkans dauert noch an und sind die Schäden jetzt so bedeutend geworden, dass mehrere Pflanzungen aufgegeben werden mussten (2, 53).

Poás

Die Tätigkeit des Poás (2678 m) in Costa Rica (s. 15, p. 172-3) war *1948-50* nur leicht und durch keine besonderen Ereignisse ausgezeichnet (3).

Irazú

Am 18. November *1948* 19.05 lokale Bebenserie am Irazú (3452 m) in Costa Rica, dabei wurden über dem Krater Lichterscheinungen beobachtet, die jedoch keine vulkanische Ursache hatten, denn bei einer kurz danach unternommenen Besteigung wurde nur die übliche Fumarolentätigkeit gefunden (3).

Purace

Das Nordende der Vulkanreihe der Sierra Cordillera Central oder Sierra Coconuco in Kolumbien bildet der 4590 m hohe Vulkan Purace. Der Eigenbau dieses Vulkans ist nur 2000 m hoch und hat einen Basis-Durchmesser von 10 × 16 km, sein ältester unterer Teil besteht aus rötlichen Daciten, die jüngsten Förderungen sind dunkle Andesite. Am Fuss finden sich Ablagerungen von Schlammströmen und Glutwolken. Nächst dem Galeras ist der Purace der am häufigsten tätige Vulkan in Kolumbien; während aber die Ausbruchschronik des Galeras bis in das 16. Jahrhundert zurückreicht, beginnt diejenige des Purace erst 1827. Explosivausbrüche sind berichtet aus den Jahren 1827, 1835, 1847-1852 (besonders stark 1849), 1869-70, 1878, 1881, 1885, 1899, 1906, 1924-29 und 1946-49. Lavaergüsse sind nicht berichtet, aber vulkanische Beben waren häufig.

Am 27. April *1947* bestieg V. OPPENHEIM den Vulkan (27). Der Gipfel war völlig schneefrei und bedeckt mit frischen Auswürflingen aller Grössen, darunter vielen grossen Lavablöcken und Brotkrustenbomben. Der tätige Krater hatte 500 m Durchmesser und war 50 m tief, darunter beginnt bereits der Steilabsturz der Bocca, die stets mit einer unter hohem Druck entweichenden Dampfsäule erfüllt war. Am gleichen Tage beobachtete OPPENHEIM eine Explosion mit 1000 m hoher Wolke, der Lapilliregen reichte 10 km weit, der Aschenregen 30 km weit bis Popayan. Die Ausbrüche dieser Periode folgten sich ohne jede Regelmässigkeit und waren von wechselnder Stärke.

Am 26. Mai *1949* erfolgte eine besonders starke Explosion mit dem Auswurf grosser Lavablöcke, während der Aschenregen wieder die Stadt Popayan erreichte. 17 Studenten der Universität Popayan, die den Vulkan an diesem Tage bestiegen, kamen durch diesen Ausbruch ums Leben. Am 11. Juni wieder stärkerer Ausbruch mit Beben (27, 55).

Tungurahua

Die Ausbrüche des Tungurahua (5087 m) in Ecuador sind seltener, aber bedeutend stärker als die seines südlichen Nachbarn Sangay. Die letzte Tätigkeitsperiode dauerte von 1916 bis 1925 und war besonders 1916 und 1918 durch bedeutende Glutwolkenausbrüche ausgezeichnet (23); nachdem zeigte der Vulkan stets kräftige Fumarolentätigkeit.

Vom 5.-7. August *1949* schwere, zerstörende Bebenserie, deren Zentrum am Nordwestfuss des Tungurahua lag. Am 7. VIII. soll auch der Vulkan in Tätigkeit getreten sein und seine Lava den Fluss Rio Patate gestaut haben. Sehr unwahrscheinlich, es handelte sich wohl nur um Erdrutsche infolge der Beben (55).

Sangay

Der Sangay (5323 m) in der Ostcordillere von Ecuador ist von 1728 bis 1916 mit nur kurzen Unterbrechungen stets tätig gewesen, dabei waren die Explosionen von sehr wechselnder Stärke und Lavaergüsse nicht selten. Zur Zeit der Ausbruchsperiode des benachbarten Tungurahua 1916 ff. stellte der Sangay seine Tätigkeit ein und blieb etwa 18 Jahre ruhig. 1934-35 fanden wieder starke Ausbrüche statt und seitdem ist der Vulkan tätig geblieben, wobei die Intensität der Ausbrüche eine sehr wechselnde war. 1937 waren die Explosionen sehr stark und 1940 sehr schwach.

1943 beobachtete Lewis (20) dicht aufeinander folgende Explosionen mit Schlackenfontänen, Aschenregen, Glutlohen, rollendem Getöse und wiederholter Gipfelschneeschmelze. Im September 1946 Auswurf grosser Lavablöcke und Aschenregen nach W hin, die dunkelgelbe Rauchfahne reichte bis zum Chimborazo und zahlreiche Fumarolen waren an der oberen Flanke nahe dem Kraterrand tätig. *1948-49* war die Tätigkeit nur leicht und besonders während des grossen Bebens vom August 1949 stark abgeschwächt. Die Förderung des Vulkans ist andesitisch (3, 20).

Quizapu

Mitte April *1949* sah W. Bachmann (6) vom Gipfel des Peteroa aus eine hohe graue Rauchsäule aus dem Krater des Quizapu aufsteigen. Dieser 3300 m hohe Vulkan in Mittelchile ist nach seinem grossen Ausbruch vom April 1932 fast immer tätig geblieben.

Llayma

Der Llayma (3082 m, s. 15, p. 174) in den chilenischen Anden, ein sehr häufig tätiger Basaltvulkan, war im September *1949* gleichzeitig mit dem Villarica wieder in starker Tätigkeit und warf Rauchwolken und Lavamassen aus (55).

Villarica

Der basaltische Villarica (2908 m) im Süden Chiles ist einer der am häufigsten tätigen Vulkane der Anden. Explosiv- und Effusivausbrüche sind berichtet aus den Jahren 1640, 1777, 1822, 1852, 1860, 1867-69, 1874-77, 1883, 1893, 1897-98, 1906-10, 1915-18, 1920-21, 1933, 1935, 1938 und 1948-49.

Anfang April *1948* wurde die Tätigkeit des Villarica plötzlich stärker, kleine Aschenexplosionen waren häufig, begleitet von unterirdischen Getösen. Am 17. Oktober dann weitere Tätigkeitsverstärkung unter Beben und am 18. X. 6.30 begann ein acht Stunden anhaltender schwerer Ausbruch mit Knallen, die sich alle 1-2 Minuten wiederholten. Bei den Explosionen wurden grosse Lavablöcke ausgeworfen und bald danach floss Lava aus dem Gipfelkrater und brachte den Gipfelschnee zum Schmelzen. Gegen 8.00 rasten vier Schmelzwasserströme an der Nordflanke herab, wurden 6-12 km lang und deckten die Strasse nach Pucon 4 km breit zu, der Fluss Rio Terao schwoll um 12 m an. Schwere Verwüstungen besonders östlich von Lago Villarica, 40 Tote, 200 Verletzte. Die Aschenförderung bei diesem Ausbruch war nur gering, gegen 16.00 Ende der Tätigkeit. Aber am gleichen Abend um 23.00 stand wieder eine 400 m hohe Glutsäule über dem Krater, die dann bis zum folgenden Morgen langsam an Stärke abnahm, aber erst am 20.X. kam der Vulkan wieder zur Ruhe (5, 55).

Anfang September *1949* trat der Villarica wieder in Tätigkeit und warf dichte Rauchwolken und Lavamassen aus (55).

PAZIFISCHE INSELWELT

Mauna Loa

Am Abend des 6. Januar *1949* begann aus einer Spaltengruppe im Südteil des Mokuaweoweo, der Gipfelcaldera des Schildvulkans Mauna Loa (4170 m) auf Hawaii, dünnflüssige Basaltlava auszufliessen, die schliesslich den Südwestrand überschritt und einen 6 km langen Strom an der oberen W-Flanke bildete. Schon 48 Stunden später was dieser Strom zum Stillstand gekommen und alle Tätigkeit ausserhalb der Caldera erloschen. Die Effusivtätigkeit innerhalb des Mokuaweoweo dauerte, erst abgeschwächt, an, aber am 23. Januar wurden wieder 270 m hohe Lavafontänen beobachtet und ein 90 m hoher Bimssteinkegel aufgeschüttet, Bimssteinlapilli fielen in einem langen Streifen nach W hin und die ganze Südhälfte der Caldera wurde mit Lava überflutet. Wieder ergoss sich die Lavaflut über den niedrigen SW-Rand der Caldera, füllte einen benachbarten kleinen Einsturzkrater aus und bildete schliesslich einen 6 km langen Strom an der Südflanke. Am 5. Februar stellten diese Fontänen ihre Tätigkeit ein, erschienen bald danach wieder und dauerte diese intermittierende Tätigkeit bis Mitte Mai 1949, wobei östlich von dem Januar-Kegel ein weiterer Schlackenkegel aufgebaut und der Calderaboden weiterhin durch Lavaergüsse erhöht wurde. Die Förderung betrug etwa 70 Mill. m^3 (21, 22).

Fast genau ein Jahr später, am 1. Juni *1950*, begann einer der grössten historischen Flankenausbrüche des Mauna Loa, diesmal auf der SW-Seite (der letzte Flankenausbruch 1942 war auf der NO-Seite erfolgt), wobei besonders in den ersten 12 Stunden ungeheure Mengen Lava ausgeflossen sind. Um 21.04 öffnete sich eine 2½ km lange Spalte im Kona-Distrikt auf der SW-Flanke in 3700 m Höhe. Sehr dünnflüssige Lava quoll in Fontänen und erhob sich darüber eine mehr als 3000 m hohe Pinienwolke aus weissen Dampfmassen, hell illuminiert von der Rotglut der Lava. Diese erste Tätigkeit dauerte etwa nur vier Stunden; inzwischen entstand um 22.15 eine neue Spaltengruppe weiter bergabwärts zwischen 3600 und 2700 m und ging die Haupttätigkeit hierher über. Eine lange, bis 100 m hohe Fontänenreihe ergoss Lava nach W und SO und bildeten sich hieraus sechs Hauptströme, zwei nach SO und vier nach W. Die westliche Lava hatte eine mittlere Fliessgeschwindigkeit von 9 m pro Stunde und erreichte der erste Strom am 2. Juni 1.02 das Meeresufer. Zwei weitere Ströme flossen am Nachmittage des 2. VI. ins Meer, welches an den Einflusstellen ins Kochen geriet. Fische wurden getötet und die Dampfsäule der Kontaktexplosionen stieg über 3000 m hoch empor. Mit abnehmender Stärke dauerte der Ausbruch bis zum 23. Juni. Der grösste westliche Strom wurde 38 km lang und bis 9 m dick. Die Förderung betrug über 500 Mill. m^3. In historischer Zeit hat der Mauna Loa nur einmal — 1859 — die gleiche Menge Lava bei einem Ausbruch ergossen. Im Februar 1951 war der dünne Oberlauf der Lava bereits kalt, Quellspalten und Unterlauf aber noch heiss (21, 53, 55).

Kilauea

Der südöstlich vom Mauna Loa gelegene Schildvulkan Kilauea (1230 m) hatte seit 1934 keinen oberflächlichen Ausbruch mehr, doch zeigen Beben und Niveauschwankungen — von dem seit 1911 bestehenden « Vulkanhaus » am Calderarand des Kilauea gewissenhaft registriert — die anhaltenden Bewegungen seiner Lavasäule an. 1944 war diese Lavasäule deutlich steigend und war mit einem Lavaerguss zu rechnen, der jedoch ausblieb. Im Frühjahr *1950*, vor dem Ausbruch des Mauna Loa, wieder deutlicher Lavadruck unter dem Kilauea, der dann durch die Eruption des grossen Nachbarn unterbrochen wurde und sich im Spätsommer kurz wiederholte. Anfang Dezember 1950 neuer, besonders starker Lavadruck unter dem Vulkan, wobei die Lava wahrscheinlich unterirdische Spalten und Hohlräume ausgefüllt hat. Die Abnahme des Druckes war dann vom 8. bis 11. Dezember von mehr als 700 Beben sowie von einer Senkung des Zentralteils des Calderabodens des Kilauea um 35 cm begleitet (21).

Isabella

Auf der Insel Isabella (Albemarle) im Galapagos-Archipel ist in der ersten Hälfte des Jahres *1948* ein Lavaerguss erfolgt. Die Galapagos-Inseln haben hawaiischen Ausbruchscharakter, zuletzt flossen dünnflüssige Lavaströme 1925-26 auf Isabella und 1936 auf Fernandina (55).

Tongoa

Die Insel Tongoa in den südlichen Neuen Hebriden besteht aus einer Gruppe sehr junger, bis 563 m hoher Vulkane aus Basalten und Andesiten. Am Nordufer liegt ein Fumarolenfeld. Zu der Tongoagruppe gehören auch mehrere kleine Inselvulkane. Der einzige in historischer Zeit tätige Krater liegt vier km nordwestlich von Tongoa in 16°50′ S und 168°32′ O an einer Stelle, wo die Seekarten eine Bank in geringer Tiefe angeben. 1897 entstand hier eine Vulkaninsel, die bald wieder verschwand. Im November 1900 neue submarine Tätigkeit mit starker Erwärmung des Meerwassers (Lavaerguss ?) und 1901 wieder kurzes Auftauchen einer Insel, 1905 war das Meerwasser hier verfärbt.

Im September *1949* wurde von einem Flugzeug aus an der gleichen Stelle eine neue Vulkaninsel von ovaler Form und 300 m grösstem Durchmesser beobachtet. Der Krater war ringsum geschlossen und erhob sich sein südlicher Rand etwa 80 m über den Meeresspiegel. Er war umgeben von einem schmalen Flachufer. Alle 10 - 11 Minuten erfolgten leichte Explosionen, deren Dampf- und Rauchsäulen nur 600 m hoch stiegen. Auch diese Insel ist bald darauf wieder von den Wellen zerstört worden, sie bestand wahrscheinlich nur aus Lockermaterial. Am 9. Juni *1950* wurden bei Lotungen an der Stelle der Insel von 1949 nur noch zwei Untiefen gefunden (40, 55).

Ngauruhoe

Der Ngauruhoe (2333 m) ist der jüngste und am häufigsten tätige Vulkan auf der Nordinsel von Neuseeland, ein einfacher Stratovulkan von regelmässiger Gestalt mit undeutlichem Sommarest. Seine Förderung ist andesitisch und sind seit der Besiedelung der Insel durch die Europäer 17 Ausbruchsperioden berichtet: 1839, 1841, 1851, 1857, 1859, 1863-71, 1875, 1878, 1881, 1886-95, 1897-98, 1907-09, 1911, 1913-26, 1928, 1934-35 und 1948-50. Die Tätigkeit war vorherrschend explosiv, Lavaergüsse fanden 1869 (?), 1881 (?) und 1949 statt. Bei den Ausbrüchen sind am Boden des grossen Gipfelkraters Sekundärkrater tätig, deren Lage und Gestalt häufig verändert wird.

Nach längerer Ruhe hatte der Vulkan im Mai *1948* einen kurzen, aber heftigen Explosivausbruch. Er begann am 2. Mai mit Aschenexplosionen aus dem am Westrand des Hauptkraters gelegenen Sekundärkrater. Tiefschwarze Rauchwolken stiegen mehrere 1000 m hoch, rotglühende Lavablöcke zersprangen während des Fluges, Aschenregen nach N hin. Am Mittag des 2. Mai folgten sich die einzelnen Explosionen in Intervallen von nur wenigen Minuten. Am Morgen des 3. Mai nahm die Tätigkeit zu, Lavablöcke von ungeheurer Grösse wurden ausgeworfen, Aschenregen fielen nach W, N und NO hin. Am Abend lange Rauchfahne nach NO, Blockregen über die Südflanke, die Asche lag am Fuss 1 cm hoch, Aschenfall 200 km nach NO bis Rotorua (52).

Der *1949* folgende Ausbruch des Ngauruhoe war vielseitiger und interressanter: ausser strombolianischer Tätigkeit und Lavaerguss wurden auch absteigende Glutwolken beobachtet; M. H. BATTEY und P. E. CLOUD haben ausführlich darüber berichtet (7, 11). Die Explosivtätigkeit begann ohne Vorzeichen in der Nacht zum 9. Februar um 1.30 mit Beben, Glutschein und Getöse, es wurden viel Lavablöcke und wenig Asche ausgeworfen. Die Explosionen erfolgten wieder aus dem westlichen Randkrater. In den Morgenstunden des 9. Februar gingen — gleichzeitig mit vertikalen Ausbruchswolken — mehrere Glutwolken an der Nordwestflanke bis fast zum Fuss nieder (Abb. bei BATTEY, Tf. 70). Gegen Abend beobachtete S. J. BLACKMORE vom Flugzeug aus, dass der tätige Krater bereits von einem flachen Lavadom mit uhrglasförmig gewölbter Oberfläche ausgefüllt war, die Dampfausbrüche erfolgten zur Zeit nur aus einer Bocca am Ostrand der Lavamasse. In der folgenden Nacht stieg die Lavasäule weiter und floss dann über die niedrigste Stelle des Kraterrandes im NW; der Lavastrom nahm den gleichen Weg wie die Glutwolken und gabelte sich am Fuss, erreichte aber das flache Vorland nicht. Am 12. II. zeigte der Strom keine Bewegung mehr. Am 11. Februar liess die Explosivtätigkeit an Stärke nach und waren die Ausbruchswolken jetzt gelblich, jedoch frischten die Ausbrüche bereits in der folgenden Nacht wieder stark auf, wobei rotglühende Lavablöcke 700 m hoch über den Krater emporgeworfen wurden, Rauchfahne nach O, dumpfes Getöse. Am 13. Februar versuchte CLOUD eine Besteigung des Vulkans, musste jedoch dicht unter dem Gipfel umkehren, da die fallenden Blöcke der häufigen Explosionen ein weiteres Vordringen unmöglich machten. Die starken Ausbrüche hielten bis Ende Februar an. Am 5. März beobachtete CLOUD den Krater vom Flugzeug aus. Der 1948 noch sehr schroff abfallende Hauptkrater zeigte jetzt infolge starker Bedeckung mit frischen Lockermassen weichere Formen. Die Kraterwände sind im O und S am höchsten, sie fehlen im W und NW fast ganz und liegen hier zwei Innenkrater, von denen der nordwestliche seit 1928 durch Zuschüttung 20 m an Tiefe verloren hatte. Unmittelbar südlich schliesst sich der gegenwärtig tätige, grössere Sekundärkrater an, der am 5. III. nur schwach dampfte und auf dessen Grund sich der durch die Explosionen stark zerstörte und mit Asche bedeckte Kopf der Lavasäule abzeichnete. Der Oberlauf des Lavastroms war völlig unter den jüngsten Auswürflingen verschwunden. Im Mai 1949 hatte der Ngauruhoe leichte Explosionen und zeitweise starke Dampfausströmungen, ausserdem zeigten sich an der Nordwand des Hauptkraters neue Fumarolen.

Den Lavastrom fand CLOUD am 12. Februar schon mit einer dunklen Kruste bedeckt, er war etwa 1900 m lang, 90 bis 140 m breit und 5 m hoch, die Oberfläche bestand aus Blöcken von 2 - 5 m Durchmesser. Ausser den beiden Seitenwällen war noch ein Mittelwall vorhanden, dieser ist dadurch entstanden, dass die Lava den Kraterrand an zwei benachbarten Stellen durchbrach und die ganze Lavamasse eigentlich aus zwei parallel laufenden Strömen bestand. Die den Strom unterlagernden und benachbarten Glutwolkenablagerungen waren scharf begrenzt und hatten eine maximale Mächtigkeit von 13 m, sie waren am 13. II. noch heiss und mit Fumarolen bedeckt, deren Temperatur bis zum Mai stark abnahm. 75 % des Glutwolkenmaterials war frisch, 25 % vom Hang mitgerissen. Die Förderung des Ngauruhoe 1949 war nach BATTEY ein olivinführender Hypersthen-Augit-Andesit und weicht von den älteren Förderungen wenig ab.

Am 3. März *1950* nach (55) gelegentlich eines Bebens wieder erhöhte Tätigkeit des Ngauruhoe.

Ruapehu

Nach seinem letzten grossen Ausbruch 1944-46 ist der dem Ngauruhoe südlich benachbarte Ruapehu (2803 m, s. 8 und 15, p. 177-178) ruhig geblieben. Am Morgen des 2. Mai *1948* beobachtete Dr. CHRISTIE vom Flugzeug aus, dass der Kratersee völlig verschlammt war und stark dampfte. Nach dem Beginn der Tätigkeit des Ngauruhoe liessen die Emanationen des Ruapehu merklich nach und am nächsten Morgen war der Vulkan völlig ruhig (52), *1949* war wieder ein heisser und stellenweise kochender Kratersee vorhanden (55).

Bagana

Der Bagana (3020 m, s. 15, p. 178-179) auf der Salomoneninsel Bougainville war im Frühjahr *1949* stets stark dampfend und hatte mehrere Explosivausbrüche mit Aschen- und Bombenauswurf, z. T. auch mit absteigenden Glutwolken (55).

ANTARKTIS

Darnley

Der Vulkan Darnley auf der Bristol-Insel in der Süd-Sandwich-Gruppe wurde von einem Walfänger aus am 27. März *1950* in eruptiver Tätigkeit gesehen. Seinen letzten Explosiv- und Effusivausbruch hatte der Vulkan um die Jahreswende 1936/37 (55).

OSTASIEN

Schiwelutsch

Der am Nordende der östlichen Vulkanreihe von Kamtschatka gelegene Schiwelutsch (3298 m) fördert im Gegensatz zu der im Süden benachbarten basaltischen Kliutschewskoy-Gruppe nur saure Andesite und Dazite. Der Vulkan stellt eine alte, vergletscherte Calderaruine dar, deren Südteil niedergebrochen ist. Auf dem Calderaboden liegt ein Aschenkegel (2597 m), der in historischer Zeit wenige schwache Ausbrüche hatte. Neben diesem Zentralkegel und auf den Flanken des Calderaberges liegen (nach KULAKOW, s. 19) mehrere Quellkuppen aus Hornblende-Andesit, deren jüngste 1854 entstanden ist. Aber die heutigen Ausbrüche sind nur noch schwache Wiederholungen früherer grosser Ereignisse. Die letzten Aschen- und Lapilliausbrüche erfolgten 1926-1930.

Ende Dezember *1944* begann eine neue Eruptionsperiode gleichen Charakters, die *1948* noch andauerte und die schliesslich ein getreues Ebenbild der Ereignisse am Pelée auf Martinique 1902 ff. wurde. In den ersten Jahren blieb die Explosivtätigkeit schwach, die Ausbrüche förderten nur Dampf und Asche und folgten sich alle 5 bis 15 Minuten, wobei die Wolken nicht höher als 2000 m über den Krater emporstiegen. Nach B. I. PIJP war es die typische Tätigkeit eines alternden sauren Vulkans und vergleicht er sie mit der des Lassen Peak. 1948 wurde der Ausbruch effusiv: An der Calderaflanke entstand eine kraterlose Quellkuppe aus Andesit. Ihr Wachstum war begleitet von häufigen Lavalawinen, seltener von den Ausbrüchen mächtiger Glutwolken aus den Kuppenspalten, die reichlich Asche mit sich führten und eine Länge bis zu 3500 m erreichten. Schliesslich wurde aus dem Kuppengipfel ein 100 m hoher starrer Obelisk ausgepresst. Die Temperatur der Lava wurde zu 900 bis 950° C gemessen. Die neue Lavamasse hat ein Volumen von 100 Mill. m³ (33, 54).

Kliutschewskoy

Dieser höchste und fast stets tätige Vulkan auf Kamtschatka hat 1932, 1938, 1945 und 1946 — meist im Anschluss an grosse Gipfelausbrüche — neue Flankenkrater gebildet, deren Tätigkeit (explosiv und effusiv) nach einigen Monaten erlosch, aber Solfataren und Fumarolen halten sich hier ungewöhnlich lange. In den Jahren 1946 bis 1948 waren deren Temperaturen zwar stets sinkend, aber eigenartigerweise erkaltete der jüngste Krater am schnellsten, während die drei ältesten (Kirguritsch oder Patzan, Tuyla oder Faina und Biokos, sie entstanden nacheinander im Januar, Juni und November 1932) ihre Hitze am besten speicherten, wie folgender Vergleich zeigt:

	1946:	*1948:*
Krater von 1932:	440° C	300° C
» » 1938:	165° C	105° C
» » 1945:	230° C	220° C
» » 1946:	1140° C	186° C

Der Gipfelkrater des Kliutschewskoy (die Höhenangaben für diesen Vulkan schwanken zwischen 4810 und 4916 m) blieb nach seinem letzen Paroxysmus 1944-45 (s. 15, p. 181-82) stets dampfend und hatte im August *1948* wieder starke Explosionen mit lautem Donner und Aschenauswurf (33, 54).

Tolbatscha

Der Schildvulkan Tolbatscha (3140 m) südlich der Kliutschewskoy-Gruppe auf Kamtschatka war 1946 bis 1948 stets dampfend und hatte im Januar *1947* nach 6 Jahren Ruhe einen Explosivausbruch. Bei einem Kraterbesuch im Sommer *1948* fand man am Kraterboden breite, meridional gerichtete Spalten, welche 1947 basaltische Sande und Lapilli ausgeworfen hatten. Ausser den Spalten waren 1948 zwei dampfende Bocchen und zahlreiche Fumarolen vorhanden (54).

Akita-Yakeyama

Am 14. und 15. August *1949* erfolgten phreatische Dampf- und Aschenexplosionen des Akita-Yakeyama (1320 m) in der Nasuzone (Japan). Der Vulkan hatte bereits 1875 und 1890 ähnliche Ausbrüche; er stellt einen Sommaberg mit Solfatarenfeldern und Gipfelquellkuppe dar, die Förderung ist andesitisch und dazitisch (24).

Azumayama

Die Vulkangruppe des Azumayama in der Nasuzone besteht aus fünf Kegeln mit zahlreichen Kratern und Fumarolen. Historische Ausbrüche sind nur von dem höchsten nordöstlichen Kegel Issaikyo (1948 m) berichtet: 1844 und 1893-96 fanden phreatische Explosionen statt und 1907 waren kräftige Solfataren und ein schwefelsaurer Kratersee vorhanden.

Am 10. und 19. Februar *1950* erfolgte ohne Vorzeichen Aschenexplosionen an der Südostflanke des Issaikyo nahe der 1893 tätigen Spalte. Dabei wurden zahlreiche kleine Krater ausgesprengt, die deutlich an drei Spalten gebunden sind. Auch diesmal wurde nur altes Oberflächenmaterial ausgeworfen. Ende Juni 1950 waren die Krater noch stark dampfend und die Maximaltemperatur der neuen und alten Fumarolen 95° C (24, 26).

Zaôsan

Unter den Vulkanen der Nasuzone ist der Zaôsan (Kattadake, Soôsan) durch seine häufige Tätigkeit ausgezeichnet. Infolge wiederholter Verschiebung des Eruptionszentrums entstanden hier zahlreiche, eng verwachsene Vulkanberge, deren höchster der Kumanodake mit 1841 m ist. Die Gesteine sind vorherrschend Augit-Hypersthen-Andesite. Das in historischer Zeit allein tätige Zentrum ist der Goschikidake (1674 m), dessen erste geologische Beschreibung T. ICHIMURA bringt (16). Der Goschikidake ist der Zentralkegel der Kattadake-Caldera (2000 m Durchmesser), er stellt eine flache Homate mit schräg abgestutztem Gipfel dar und sein Krater, Okama, ist mit einem 300 m breiten See gefüllt, dessen Tiefe 1939 zu 63 m gemessen wurde. Seine Tätigkeit ist sehr ähnlich derjenigen der Kawah Idjen auf Java. Während die älteren Zaôsan-Krater viel Lava förderten, hat sich der Goschikidake ancheinend nur aus Lockermaterial aufgebaut. Die historischen Ausbrüche waren leichte Explosionen aus dem Okama, dessen Wasser dabei schweflig wird und mehrmals überfloss: 884, 1230, 1331-33, 1623, 1624, 1669, 1821, 1867, 1873, 1890, 1894, 1895, 1897, 1906 (?), 1918, 1923, 1927 und 1939. Im Gefolge der letzten Tätigkeit entstanden im April 1940 am NO-Fuss des Goschikidake kräftige Fumarolen mit reichlicher Förderung von Stickgasen. Im Juli *1950* fand T. ICHIMURA diese Fumarolen immer noch stark tätig und 90° C heiss, sie förderten jetzt in der Hauptsache Wasserdampf mit einer geringen Beimischung von SO_2.

Asamayama

1949 war der Asama (2554 m) im August und September tätig: stärkste Explosion am 3. September mit ausgedehntem Aschenregen (24).

Im September und Oktober *1950* folgte eine weitere Ausbruchsperiode. Die Explosion am Morgen des 23. September war eine der stärksten der letzten Jahrzehnte, mit 10000 m hoher Rauchsäule, Aschenregen nach O bis zum Stillen Ozean, die Detonation war 300 km weit nach O, W und S hin zu hören. In Karuizawa am Südfuss des Asama zersprangen infolge der

Lufterschütterung die Fensterscheiben. Am 4. Oktober folgte ein weiterer starker Ausbruch (18, 24).

Yakeyama

1949 hatte der Yakeyama (2400 m) in der Myôkô-Vulkangruppe nordwestlich vom Asama nach einer Ruheperiode von 95 Jahren eine Reihe phreatischer Ausbrüche. Die erste Explosion am 5. Februar war die stärkste, weitere folgten am 7. und 15. Februar und am 13. September: Aschenfälle, Detonationen, Beben; aus dem Auswurfsmaterial bildeten sich später an der Ostflanke Schlammströme. Die Ausbrüche sprengten an der oberen Nordflanke eine Reihe von Explosionskratern und Spalten aus, deren Fumarolen im August '49 92.5° C heiss waren. Obgleich die Explosionen nur altes Material auswarfen, lag ihre Ursache doch im Magmaherd, wie die einleitenden starken Beben beweisen, die z. B. bei der Azuma-Explosion fehlten (24, 39).

Miharayama

Der Miharayama auf der Insel Oosima in der Izugruppe (Fujizone, Japan) ist ein 755 m hoher Sommaberg mit vorherrschend effusiver Tätigkeit. Strombolianische Ausbrüche begannen hier nach 10 Jahren Ruhe am 16. Juli *1950* 10.00 und dauerten ohne Unterbrechung 70 Tage bis zum 23. September. Dabei wurde der Krater des Zentralkegels aus mehreren Quellen mit Blocklava (ein olivinfreier Basalt mit 52.25 bis 52.68 % SiO_2) angefüllt und waren nacheinander zwei Schlackenkegel tätig, die sich 50 und 100 m hoch aufbauten, der erste erlosch am 23. August und gleich danach entstand an seinem Südfuss der zweite. Ihre Explosionen folgten sich in Intervallen von wenigen Sekunden und förderten reichlich Schlacken und Bomben, während die Aschenförderung unbedeutend blieb. In dem neuen Lavafeld wurden Temperaturen von 1000° bis 1100° C gemessen. Kleine Lavaströme flossen ab 12. September über die niedrigsten Stellen des Kraterrandes im W und N und erreichten das Atrio. Später bis Jahresende anhaltend seismische Unruhe (24, 25, 53).

Asoyama

Der Zentralkegel Nakadake (1690 m) in der Aso-Caldera war vom Juli bis Dezember *1948* leicht explosiv tätig und *1949* blieb der Vulkan bis zum Dezember ruhig. Am 26. XII. begannen starke strombolianische Ausbrüche, am 27. wurden glühende Bomben 250 m hoch emporgeworfen; im Laufe von 24 Stunden erfolgten 475 Explosionen, die Rauchsäule war durch Lavaglut erleuchtet und alle drei Minuten ging ein Aschenschauer in der Umgegend nieder. Die Tätigkeit dauerte bis April *1950* und liess ihre Stärke im Laufe dieser Monate langsam nach, später bildete sich ein heisser See am Kraterboden. Das Zentrum der Tätigkeit war der nördlichste der vier Kraterschächte (24).

Sakurasima

Nach seinem grossen Ausbruch vom März-April 1946 ist der Sakurasima (1120 m) in der Bucht von Kagoschima ruhig geblieben und hatte erst wieder vom 4. Juli bis 10. August *1950* eine Reihe mittelstarker Explosionen mit Förderung frischer Asche (24).

Taal

Der Taal (320 m) südlich von Manila auf der Insel Luzon ist nach seinem zerstörenden Explosivausbruch vom Januar 1911 ruhig geblieben; der weite Krater füllte sich mit einem Regenwassersee, an dessen Boden einige schwache Fumarolen tätig waren. Erst im April *1949* trat wieder erhöhte Tätigkeit ein: Vulkanische Beben, Spaltenbildungen, Gedröhn, Abrutsche von der südlichen Kraterwand, zunehmende Solfatarentätigkeit und das Seewasser begann am Süd- und Westufer zu kochen (55).

Hibok Hibok

Am 1. September *1948* begann nach kurzer Bebenvorbereitung eine Serie heftiger Aschenausbrüche aus dem Vulkan Hibok Hibok auf der kleinen Insel Camiguin vor der Nordküste von Mindanao in den Philippinen. Das Zentrum der Tätigkeit war das 1897 entstandene Solfatarenfeld an der oberen Nordostflanke. Erdrutsche, Schlammströme und Glutwolken traten auf, Lava brach durch und bildete erst einen Lavadom, dann einen breiten Lavastrom an der Nordostflanke, der, sehr zähflüssig, bis zum Frühjahr 1949 in Bewegung blieb. Während dieser Zeit fanden öfters leichte Explosionen statt, z. T. begleitet von Glutwolken.

Im Juni *1949* folgten wieder stärkere Glutwolkenausbrüche, welche diesmal mehr nach der Ostflanke gerichtet waren. Hiernach bildete sich ein neuer Lavadom in der Gipfelgegend, aus dem ein kleiner Lavastrom nach der Ostflanke abfloss.

Am 15. September *1950* plötzlicher starker Glutwolkenausbruch, wobei 66 Personen getötet wurden. Es wurde viel Asche ausgeworfen und auch nach diesem Ausbruch entstanden in der Gipfelregion neue Lavaextrusionen (1, 55).

Der Vulkan Hibok Hibok ist identisch mit dem 1462 m hohen Catarman an der Nordküste der Insel. Um 1897 entstanden an seinem Gipfel neue Solfataren und 1871-76 bildete sich an seinem Nordfuss ein 617 m hoher Dom aus sehr zähflüssiger Lava (Augit-Hornblende-Andesit), auf dessen Gipfel noch 1948 leichte Fumarolen tätig waren.

Siaoe

W. A. PETROESCHEWSKY hat eine übersichtliche Liste der Ausbrüche der indonesischen Vulkans bis zum ersten Halbjahr 1950 zusammengestellt (32), nach welcher der Goenoeng Api auf der Insel Siaoe (1784 m, Sangihe-Reihe) auch *1948* und *1949* tätig war.

Roeang

Im Januar *1949* hatte der Inselvulkan Roeang (725 m) in der Sangihe-Reihe einem heftigen Explosiv- und Effusivausbruch. Die letzte erhöhte Tätigkeit war 1946 (32, 55).

Lokon

1948 und *1949* war nach (32) der 1580 m hohe Lokon auf der Halbinsel Minahassa (Celebes) in erhöhter Tätigkeit; der letzte grössere Ausbruch des andesitischen Doppelvulkans war 1942.

Kariang (*Doekoeno*)

Seit August 1933 ist der Kariang (1335 m) im Doekoenogebirge auf der Insel Halmaheira ununterbrochen in Tätigkeit und hat diese auch *1948-50* mit geringen Unterbrechungen fortgesetzt. Die Aschenförderung ist zurückgegangen und wird jetzt mehr Lava geliefert (9, 32, 38).

Gamkoenora

Der 1635 m hohe Andesitvulkan Gamkoenora an der Nordwestküste von Halmaheira war nach PETROESCHEWSKY's Liste (32) *1948* in erhöhter Tätigkeit und hatte *1949* einen Ausbruch. Ältere Ausbrüche sind berichtet aus den Jahren 1564, 1673 (stark), aus den 1880er Jahren, 1911, 1917 und 1926.

Siroeng

Der 862 m hohe Siroeng auf der Insel Pantar befand sich nach (32) *1948* und *1949* in erhöhter Tätigkeit.

Lama Heroe (*Ili Weroeng*)

Am 7. Mai *1948* hatte der Lama Heroe auf der Südosthalbinsel von Lomblen (s. 15, p. 187-188) nach Bebenvorbereitung eine heftige Explosion mit Glutwolken, wobei der Lavadom Ili Weroeng zum Teil zerstört wurde und vier neue Explosionskrater entstanden. Am 9. Mai folgte eine weitere Explosion, wobei östlich vom Ili Weroeng ein weiterer neuer Krater und darin ein Lavadom entstand, der Ili Gripe oder Ili Petrus. Am 7. Juni waren die vulkanischen Neubildungen noch stark dampfend (9, 32), Tätigkeit bis November '48 anhaltend.

Ili Boleng

Der wenig bekannte Vulkan Ili Boleng (Ili Lamahelang, Wokka, 1659 m) auf der Insel Adonara war nach (9) und (32) 1885, 1888, 1904, 1909, 1925, 1927, 1944, 1947, *1948* (27. April) und *1949* tätig.

Lombok

1945 bis *1948* erhöhte Tätigkeit des Rindjani-Kraters (3726 m) auf der Sundainsel Lombok. In diesem Krater war

1944 ein Lavadom auf einer Spalte entstanden, der im Juni *1950* einen Basis-Durchmesser von 2000 m und eine Höhe von 175 m über dem Kraterseespiegel erreicht hatte (32, 55).

Kawah Idjen

Im ersten Halbjahr *1950* erhöhte Tätigkeit der Kawah Idjen (2386 m) in Ostjava (32).

Bromo

Der Bromo (2392 m) im Tenggergebirge auf Java befand sich 1943 in erhöhter Tätigkeit, hatte vom 15. Februar bis 27. März *1948* einen heftigen, von Beben begleiteten Ausbruch und war auch *1949* und *1950* wieder tätig (9, 32).

Keloed

Der 1731 m hohe Keloed auf Java befand sich nach (32) im ersten Halbjahr *1950* in erhöhter Tätigkeit.

Merapi

Der Merapi (2911 m) in Mitteljava war nach (32) auch 1944, 1945, *1948* und *1949* tätig.

Slamat

Der Slamat (2432 m) in Mitteljava hatte nach PETROESCHEWSKY's Liste (32) 1943, 1944, *1948* und *1949* Ausbrüche. Die Tätigkeit des Vulkans in historischer Zeit war nur explosiv, seine Förderung ist basaltisch.

Tjerimai

Der 3077 m hohe Tjerimai in Mitteljava war nach (32) *1949* in erhöhter Tätigkeit.

Tangkoeban Prahoe

Dieser Vulkan im nordwestlichen Java hat mehrere über einer Ost-West-Spalte gelegene Krater, unter denen der Kawah Ratoe der am häufigsten tätige ist (2084 m). Der letzte grössere Ausbruch hier war 1910; 1946 und 1947 befand sich der Vulkan in erhöhter Tätigkeit und Anfang Juli *1950* stiegen die Solfatarentemperaturen plötzlich wieder über 200° C (32, 55).

Gedeh

1948 und *1949* hat der Gedeh (2958 m) in Westjava seine seit 1946 andauernde Eruptionsperiode fortgesetzt, wobei aber noch kein frisches Material gefördert wurde. Eine besonders starke Explosion fand am 25. Januar 1948 statt (9, 32).

Krakatau

Nach PETROESCHEWSKY's Liste der Ausbrüche der indonesischen Vulkane (32) war der Krakatau in der Sundastrasse von 1927 bis 1947 tätig und wieder *1949* und *1950*. Nach (55) wird die Höhe der seit 1929 langsam, aber stetig wachsenden neuen Vulkaninsel Anak Krakatau im September 1949 zu 145 m angegeben (1941: 132 m, s. 15, p. 192). Vom Flugzeug aus beobachtete man ein Kochen des Kratersees an der Westseite und gelegentlich auch ein Emporwerfen des Wassers wie ein Geiser. Auf dem nicht vom See bedeckten Teil des Kraterbodens lagen kleine Teiche mit rötlichem Wasser, umgeben von einem Kranz von Fumarolen mit gelben Sublimationen. Die Förderung von Schwefeldampf war bedeutend.

Am 4. Juli *1950* hatte der Krakatau vier heftige Explosivausbrüche, wobei glühende Auswürflinge 800 m hoch emporgeschleudert wurden (55).

Kaba

Der Vulkan Kaba (1952 m) im südlichen Teil der Insel Sumatra, zuletzt 1941 tätig (s. 15, p. 193), war nach (32) auch im ersten Halbjahr *1950* wieder in eruptiver Tätigkeit.

Marapi

Der 2892 m hohe Marapi oder Merapi auf Sumatra hat auf seinem flachen Gipfel eine grosse Anzahl Krater, die durch das Wandern des Eruptionszentrums von O nach W nacheinander entstanden sind. Der westliche jüngste Krater, Kapoendan Bongsoe, hatte nach 17 Jahren Ruhe *1949* wieder einen Ausbruch (32).

AFRIKA

Piton de la Fournaise

Der sonst hauptsächlich effusiv tätige Piton de la Fournaise (2635 m) auf der Insel Reunion hatte im Oktober *1949* einen starken Explosivausbruch mit ausgedehntem Aschenregen (55).

Karthala

Der basaltische Schildvulkan Karthala (Ngazia, 2450 m) in den Komoren hatte im 19. Jahrhundert mehrere Flankenausbrüche, während seine kleeblattförmige Gipfelcaldera nur selten tätig war. 1904 wieder Flankenausbruch an der Nordseite und 1918 erfolgten starke Explosionen aus der Caldera, nachdem zeigte der Vulkan 30 Jahre lang nur Fumarolentätigkeit am Gipfel und in Flankenspalten im N und NO.

Am 22. April *1948* beobachtete man erstmals wieder eine gluterleuchtete Rauchsäule über der Gipfelcaldera. An den folgenden Tagen nahm die Tätigkeit schnell zu und erreichte am 1. und 2. Mai ihr Maximum, wobei die Glutsäule bis 400 m über den Kraterrand stieg. Die Ausbrüche endeten am 4. Mai, ohne dass es zu einem Lavaerguss kam. Tätig war allein ein Schachtkrater von 150 m Durchmesser am Calderaboden, der sich mit einem Lavasee gefüllt hatte. In Intervallen von einer Minute geriet der Lavaseespiegel in Wallung, dann erfolgte eine Dampfexplosion, die Schlacken und wenig Asche von der Oberfläche mit empor riss. Die Schlacken waren von Faust- bis Kopfgrösse, glasig, kompakt und flogen nur 100 m hoch. Schwefelgeruch war weithin wahrzunehmen. Am 14. Mai war der Lavasee verschwunden und der Krater stiess jetzt reichlich Wasserdampf aus. An einer der dampfenden Spalten am Nordabhang wurden ebenfalls frische Schlacken gefunden. Von den beiden Einsturzschächten am Boden der Gipfelcaldera war nur der nördliche tätig gewesen, der dicht benachbarte südliche blieb von dem Ausbruch unbeeinflusst und zeigte am Boden einen Regenwasserteich (34).

Nyamlagira

Der westlichste der Virunga-Vulkane in Zentral-Afrika, der Nyamlagira (Nyamuragira, 3058 m), ein Schildvulkan mit

Förderung von dünnflüssigen Leuzitbasalt, wurde erst 1894 von GRAF VON GÖTZEN entdeckt und ist seitdem fast stets tätig gewesen. Meist sind nur kleine Lavaseen im Gipfelkrater tätig, seltener sind grosse Explosionen (1907) und Flankenausbrüche: 1904, 1905 und 1912-13, bei dem letzten entstand der Lateralkegel Katerusi (Ntsuro, Rumoka) am Nordufer des Kiwusees, er liegt zwar näher am Nachbarvulkan Nyiragongo, gehört jedoch petrographisch zum Nyamlagira. Der letzte grosse Ausbruch des Nyamlagira währte vom Januar 1938 bis Juni 1940 und förderte 1 Milliarde m^3 Seil- und Fladenlava aus einer Spalte an der oberen SW-Flanke (13).

1948 bildete sich ein neuer Satellit am Südfuss zwischen den 1904 und 1912 entstandenen Kegeln, der Kituro (Kineza, Kituro-Nyefunsi). Nach einem heftigen Beben am 29. Februar entstand eine 6 km lange, O-W gerichtete Spalte in 1750 m Höhe südlich von dem 1904 enstandenen Satelliten Nahimbi. Erst in den Morgenstunden des 1. März begannen hieraus die Ausbrüche von Gasen und Lava. Die Hauptzentren der Tätigkeit bildeten sich an den beiden Spaltenenden heraus. Insgesamt waren 6 Bocchen tätig, darunter 2 effusive. Die Lavafontänen erreichten zeitweise eine Höhe von 300 m. Schwere Bomben fielen 300 m weit und zersprangen beim Aufprall. Hohe Flammen von orangeroter Farbe wurden beobachtet. Die Gasförderung war bedeutend, aber die Aschenfälle gering. Die ausfliessende Lava war anfangs Fladenlava, später Blocklava. Die erste und heftigste Phase der Eruption dauerte 10 Tage; am 10. März war der östliche Lavastrom schon 10 km lang. Erst im Laufe des April bildete sich über einer der explosiv tätigen Bocchen im östlichen Teil der Spalte ein deutlicher Schlackenkegel, der Kituro. Am 15. April bestieg H. TAZIEFF den kleinen Vulkan und sah am Kratergrund einen Lavasee, dessen Spiegel in gleicher Höhe lag, wie das Umland. Dieser Lavasee leuchtete in kirschroter Farbe und war in dauernder Bewegung, die ausströmenden Gase rissen wenige Schlacken mit empor. Am 3. Mai erfolgten die kleinen Explosionen aus dem Ostteil des kleiner gewordenen Lavasees. Die Auswürfe waren häufig schräg gerichtet und demzufolge der Kraterrand ungleich hoch. Nach dem Versiegen der ersten Lavaquellen brachen am 6. und 29. Mai neue Quellen auf und ergossen ihre Lava über die älteren Felder. Westlich vom Kituro waren nur wenige kurze Strömchen aus der Spalte geflossen und stellenweise Schweisschlacken ausgeworfen, nur am Westende der Spalte war bei Muhuboli ein grösserer Strom ausgeflossen, der z. T. die Lava von 1938-40 bedeckte und das Ufer des Kiwusees erreichte. Nach einer vorübergehenden Verstärkung Anfang Juni folgte eine allgemeine Abnahme der Tätigkeit. Am 15. Juni war der Kituro 80 m hoch und zeigte an seinem Kraterboden vier kleine dampfende Bocchen. Die Temperatur der Lava wurde zu 1050° bis 1150° C und die der Gase zu 1020° bis 1090° C gemessen (42, 48, 49).

Nyiragongo

Der südöstliche Nachbar des Nyamlagira, der 3470 m hohe Nyiragongo (Niragongwe), liefert ebenfalls leuzitführende Gesteine, er stellt einen lavareichen Stratovulkan mit drei grossen Gipfelkratern dar, deren mittlerer der höchste und seit seiner Entdeckung 1894 fast immer tätige ist. Dieser Krater ist jedoch der typische Schacht eines Schildvulkans mit senkrecht abstürzenden Wänden und ebenem Lavaboden. Auf diesem Boden lagen 1894 und später zwei kleine Schächte, in denen sich die Tätigkeit des Vulkans konzentrierte. 1927 wurde die dünne Wand zwischen den beiden Schächten zerstört, später ist noch ein dritter Schacht entstanden und dieses Kleeblatt vereinigte sich schliesslich zu einem grossen ovalen Innenschacht.

Am 10. Juni *1948* haben H. TAZIEFF und G. TONDEUR den ersten Einstieg in den Gipfelkrater des Nyiragongo unternommen. Dieser Krater hat 700 × 800 m Durchmesser und ist bis 200 m tief, er war 1948 meist von Dämpfen erfüllt und allnächtlich heller Glutschein sichtbar. Der Abstieg über die unter 65° bis 80° geneigte Kraterwand dauerte 2½ Stunden. Diese Wand besteht aus alternierenden Lagen von Lavaströmen und Tuffen. Die Wand und der ebene, aus Lavaströmen gebildete Kraterboden sind durch eine schmale Spalte getrennt, aus der Schweisschlacken ausgeworfen wurden. Den zentralen Innenschacht umgeben konzentrische Spalten und dieser selbst hatte etwa 400 m Durchmesser und bis 200 m Tiefe, auch hier sind die Wände fast senkrecht und zeigen ebenso wie die Wände des grossen Kraters nur wenig Schutthalden. In der NW-Ecke des Schachtbodens lag ein mit einer schwarzen, elastischen Kruste bedeckter Lavasee in Form eines Halbmondes mit einer Ausdehnung von 300 × 150 m. Südlich von ihm lagen mehrere kräftige Solfataren, die zeitweise auch Schlacken auswarfen. Die Lavaseekruste wurde periodisch von rotleuchtenden Fontänen durchbrochen und die Ostseite des Schachtbodens war von frischen Lavaergüssen bedeckt. Die gegenwärtige Lavaförderung des Vulkans ist reich an Leuzit, aber deutlich verschieden von der des Nyamlagira und des Kituro (41).

1950 war wieder ein Lavasee im Krater des Nyiragongo tätig und häufig Glutschein über ihm sichtbar (55).

ATLANTISCHE INSELN

Hekla

Der grosse Ausbruch der Hekla (s. 15, p. 195-198) dauerte *1948* noch bis zum 25. April, nachdem nur noch Fumarolentätigkeit. Im Mai und Juni traten in der Umgegend des Vulkans auch Mofetten auf. Inzwischen ist weitere Literatur über den Ausbruch erschienen (44, 45, 46, 47).

La Palma

Der Lavaausbruch auf der Kanareninsel La Palma erfolgte nach einer Ruhe von 237 Jahren, seit Entdeckung der Insel sind hier Ausbrüche aus den Jahren 1585, 1646, 1677-78 und 1712 bekannt. *1949* war eine S-N laufende Spalte auf dem südlichen Gipfelkamm der Insel tätig. Zuerst entstand am 24. Juni ein Doppelkrater an deren Südende nördlich der Montana Pelada, der Lavablöcke und Asche auswarf und dessen Tätigkeit besonders Ende Juni von starkem Getöse und Beben begleitet war. Am 8. Juli stellte der Doppelkrater seine Tätigkeit plötzlich ein und zugleich entstand etwa 4 km weiter nördlich der Krater Llano del Banco, dessen Explosivtätigkeit gering blieb, der aber die grösste Menge der Lava dieser Eruption lieferte. Dieser auch am Tage hellglühende Lavastrom Rio de la Muerta floss unter Kontaktexplosionen nahe dem Hafen Puerto Naos an der Westküste ins Meer, wobei Lavablöcke mehrere 100 m hoch geschleudert wurden. Am 25. Juli stellte der Llano del Banco seine Tätigkeit ein. Am 12. Juli entstand im Südteil der Spalte nahe dem

Doppelkrater vom 24. VI. ein weiterer Schlot, der Hoyo Negro, der bis Ende Juli explosiv tätig blieb und Asche, Lapilli und Bomben auswarf. Hier floss keine Lava aus, der Hoyo Negro bildete einen elliptischen Krater in etwa 1800 m Höhe und stiegen aus seinem in der Spaltenrichtung langgestreckten Grund oft vier Rauchsäulen nebeneinander auf. Dieser Krater hatte 250 × 300 m Durchmesser, seine Rauchsäulen stiegen bis 3000 m hoch auf und liessen reichlich Asche fallen. Den Abschluss der Periode bildete ein kurzer Lavaausbruch aus dem südlichen Doppelkrater am 30. Juli, dessen Strom an der Ostflanke des Palma-Kammes herabfloss, das Meer aber nicht erreichte. Im August 1949 nur noch Fumarolentätigkeit in den Kratern. Die Förderung der Eruption betrug über 50 Mill. m^3 (14, 55).

EUROPA

Ätna

1948 blieb der Ätna ruhig; der im Oktober 1945 entstandene Einsturzschacht im Zentralkrater vergrösserte sich und der NO-Krater stiess Wasserdämpfe aus. Im Laufe des Jahres 1949 Abnahme der Dampfemission in beiden Kratern.

Im Dezember *1949* folgte dann ein kurzer starker Gipfel- und Flankenausbruch. In der Nacht vom 30. November zum 1. Dezember Bebenserie, am Morgen des 2. XII. 5.36 stieg nach drei heftigen Erdstössen eine gluterleuchtete Aschensäule aus dem Zentralkrater auf. Um 6.30 öffnete sich eine Spalte an der oberen Südflanke des Gipfelkegels und gleich darauf auch an der Nordflanke und zahlreiche Bocchen stiessen ausser Asche auch Lava aus, während der sonst so tätige NO-Krater ruhig blieb. Um 7.00 begann ein Aschenregen über Catania, der fast drei Stunden dauerte. Die Blocklava aus den südlichen Bocchen erreichte sehr schnell die Höhenlinie 2340 m und floss dann langsamer, an der Nordseite floss veniger Lava bis zur Höhenlinie 2500 m. Tätig war eine S-N-Spalte, die den Zentralkrater genau in der Mitte durchquerte. Am 3. XII. 8.00 waren die Ströme dieser Gipfelspalte schon zum Stillstand gekommen. Aber schon am 2.XII. 22.30 hatte sich nach einem starken Erdstoss eine weitere Spalte an der oberen NNW-Flanke beim Mte. Guardirazzi geöffnet, welche sofort reichlich Lava ergoss, die sich sehr schnell ausbreitete und die Lava von 1918 bedeckte. Dieser Strom wurde 9600 m lang und erreichte die Höhenlinie 1460 m. Am folgenden Tage Abnahme des Lavaausflusses und am gleichen Abend nahm der NO-Krater seine Explosivtätigkeit unter Gluterscheinungen wieder auf. Die Spaltenausbrüche waren damit beendet; nur der NO-Krater blieb weiter tätig und Prof. CUMIN beobachtete bei dessen Explosionen verschiedentlich schöne Rauchringe. Der erste Lavaausbruch war an eine kurze, den Gipfel querende Spalte gebunden, deren Nordende sich 16 Stunden nach Ausbruchsbeginn nach NNW verlängerte, die Gesamtlänge der Spalte war 3600 m. Im Ganzen waren 18 Bocchen auf der Spalte entstanden, von denen die südlichsten phreatische Explosionen hatten. Weitere 5 Bocchen lagen in der NW-Verlängerung am Mte. Guardirazzi. Die Laven waren fast überall Blocklaven, nur wenige Stellen waren als Seillava ausgebildet. Die neue Lava bedeckte eine Fläche von 407 ha, ihr Volumen: 11 Mill. m^3 (12).

Im Januar *1950* anhaltende Explosivtätigkeit des schüsselförmigen NO-Kraters, während der Zentralkrater und die Spalte vom Dezember 1949 stark dampften (50).

Am 25. November 1950 begann nach erhöhter Tätigkeit des NO-Kraters der bisher stärkste Flankenausbruch des Ätna im 20. Jahrundert. Vergl. die Arbeit von Prof. CUMIN: *L'eruzione laterale etnea del novembre 1950 - dicembre 1951*, im Bulletin volcanologique, II/XV, im Druck.

Stromboli

1949 war der Stromboli (926 m) im März und Juni in erhöhter Tätigkeit: Lavaergüsse über die Sciara del Fuoco, die Gipfelbocchen warfen viel Schlacken und wenig Asche aus, eine besonders heftige Explosion fand am 6. Juni statt (55).

Am 21. Oktober *1950* wieder stärkerer Ausbruch: Mehrere Stunden lang heftige Aschenexplosionen unter Glutschein und Lavaerguss über die Sciara (55).

Über die starken Ausbrüche des Stromboli im August 1941, Dezember 1943 und Januar, Februar, Juni und August 1944 hat Prof. PONTE berichtet (35).

Vesuv

Der Vesuv hat in den Jahren nach seinem letzten Paroxysmus 1944 eine kräftige Fumarolentätigkeit entwickelt, z. T. mit sehr hohen Temperaturen, wie Prof. PARASCANDOLA bei mehreren Kraterbesuchen feststellte. Auffälligerweise ist der grösste Teil des schuttbedeckten Kraterbodens frei von Exhalationen, nur in seiner NW-Ecke liegt die grosse « Fumarole Mercalli ». Weitaus mehr Fumarolen finden sich an der oberen Kraterwand in dem 1944 abgelagerten Material, besonders auf der NW-, N- und NO-Seite. Die Gase sind Chlorwasserstoffsäure, Salzsäure und Schwefelwasserstoff, Sublimationen sind stellenweise reichlich vorhanden. Maximaltemperaturen: 18. März 1947: 335° C am Kraterrand; 20. Juli '47: 331° C ebenda; 9. November '47: 360° C ebenda; 22. November '47: 236° C am oberen Nordhang; 8. Februar *1948*: 400° C am Kraterrand; 15. Februar '48: 255° C am oberen Westhang; 20. November *1949*: 570° C an der oberen Ostflanke und am 20. Dezember '49: 580° C ebenda (28, 29, 30, 31).

Besonders hinweisen möchte ich noch auf eine genaue und übersichtliche Geschichte der Tätigkeitsperiode des Vesuv von 1913 bis 1944, welche Prof. IMBÒ, Direktor des Vesuv-Observatoriums, im 5. Band der Annali dell'Osservatorio Vesuviano bringt (17); der gleiche Band enthält ausserdem eine Geschichte des hundertjährigen Observatoriums und weitere Arbeiten über den Vulkan.

Santorin

Am 25. März *1948* fiel ein feiner gelber Schwefelstaubregen im südlichen Griechenland, der von dem Vulkan auf Santorin stammen soll (55).

Am 15. Januar *1950* stiegen grosse, schwefelfarbige Rauchwolken von dem Santorin-Vulkan auf (55). Über den Ausbruch des Santorin-Vulkans 1950 vergl. die Arbeit von Prof. GEORGALAS: *L'éruption du Volcan de Santorin en 1950*, im Bulletin volcanologique, II/XIII, p. 39-55.

Kumani

Am 7. Dezember *1950* fand ein heftiger Ausbruch des Schlammvulkans Kumani am Westufer des Kaspischen Meeres statt. Diese submarine Salse förderte unter Flammensäulen und Aschenregen 4 Mill. m^3 Schlamm und bildete eine 1000 × 100 m grosse Insel. Ähnliche Ausbrüche waren 1860, 1927, 1938 und 1939 (55).

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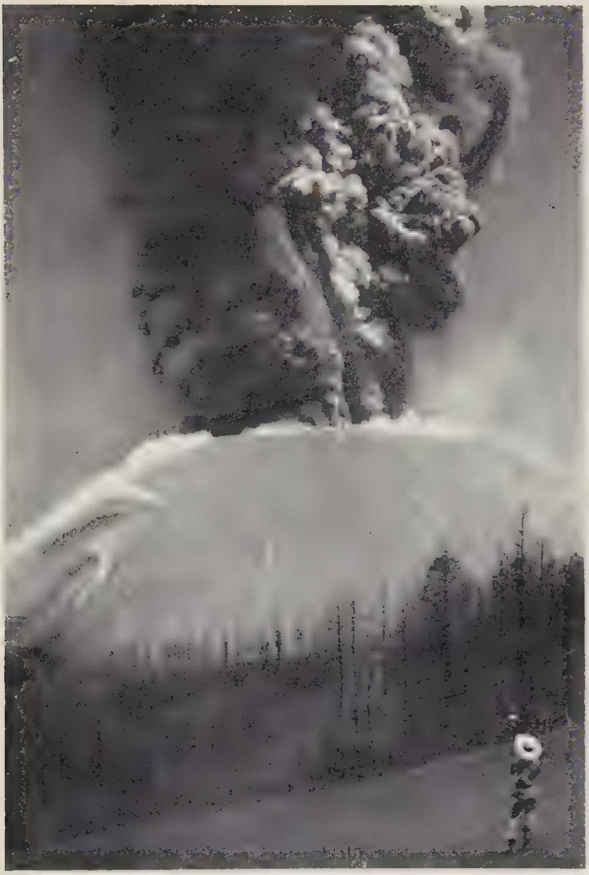

Der Paricutin im Aschenausbruch zur Zeit seiner stärksten Paroxysmen im Mai 1944.

NÉCROLOGIES

FERDINAND von WOLFF

NÉCROLOGIES

FERDINAND VON WOLFF

Am 7. April 1952 verstarb im Alter von 77 Jahren der Direktor des Mineralogisch-Petrographischen Instituts der Martin Luther-Universität Halle-Wittenberg, Professor Dr. Ferdinand von WOLFF, Mitglied der Akademie der Naturforscher (Leopoldina) und Ehrenmitglied der Deutschen Mineralogischen Gesellschaft.

Wir verlieren in ihm einen Forscher und Wissenschaftler. der weit über die Grenzen Deutschlands hinaus durch seine vulkanologischen und petrographischen Arbeiten bekannt geworden ist.

Nach zwei Studiensemestern in Leipzig absolvierte er sein Studium an der Universität Berlin und promovierte dort im Jahre 1899 unter dem Kristallographen und Mineralogen Carl KLEIN mit dem Thema: « *Beiträge zur Geologie und Petrographie Chiles unter besonderer Berücksichtigung der beiden nördlichen Provinzen Atacama und Coquimbo* ». Bereits in dieser Arbeit beschäftigte er sich mit der Frage der petrographischen Systematik und kam zu dem Schluss, dass zwischen mesozoischen und tertiären Eruptivgesteinen kein wesentlicher Unterschied besteht, so dass auch kein zwingender Grund vorliegt, die älteren und jüngeren Gesteine mit verschiedenen Namen zu belegen.

Gerade die Fragen der Gesteinssystematik beschäftigten ihn neben vulkanologischen Problemen bis in sein hohes Alter. Mit seiner Habilitationsschrift: « *Die älteren Gesteine der ecuadorianischen Ostkordillere, sowie die des Azuay und der Cuencamulde* » erwarb er sich im Jahre 1903 die Lehrbefugnis für Mineralogie und Petrographie. Seine Lehrtätigkeit begann er im Jahre 1907 an der Technischen Hochschule in Danzig, wo er die Mineralogie und Geologie zu vertreten hatte. Am 12. August 1914 erfolgte dann die Ernennung zum ordentlichen Professor an der Universität Halle. Fast 40 Jahre war er Inhaber des Lehrstuhles für Mineralogie und Petrographie in Halle und konnte auf nahezu 50 Jahre fruchtbare Lehr- und Forschertätigkeit zurückblicken, nachdem es ihm im Jahre 1949 vergönnt war, sein goldenes Doktorjubiläum zu begehen.

Die grösste Bedeutung Ferdinand von WOLFFS liegt zweifellos auf dem Gebiete der Vulkanologie. Bereits in Berlin wurde dafür sein Interesse wach gerufen, als A. STÜBEL jene These des Vulkanismus aufstellte, dass das Magma beim langsamen Erstarren vorübergehend ein Stadium der Volumenausdehnung durchläuft. Obwohl die Stübelsche Theorie zunächst begeisterte Anhänger fand, wurde die Annahme einer Volumenvermehrung später durch Volumenmessungen an Basaltschmelzen eindeutig widerlegt.

Die ersten grösseren vulkanologischen Arbeiten Ferdinand von WOLFFS erschienen in den Jahren 1902, 1904, 1905 und 1908 über den Bozener Quarzporphyr und über eine pantelleritartige Liparitlava vom Major Island, Neuseeland. Für den Bozener Quarzporphyr konnte F. von WOLFF eine Gliederung und Eruptionsfolge aufstellen und zeigen, dass die Eruptionen des Porphyrs submarin erfolgt sind.

In der Folgezeit erschienen weitere Arbeiten vulkanologischen Inhalts. Aus dem Schriftenverzeichnis F. von WOLFFS, das insgesamt 86 Veröffentlichungen umfasst, kann man entnehmen, dass allein 32 Arbeiten vulkanologischen Fragen gewidmet sind. Sein Hauptlebenswerk wurde das Handbuch des Vulkanismus, von dem bereits in den Jahren 1913 und 1914 die ersten Bände über die vulkanologischen Erscheinungen der Tiefe und der Oberfläche erschienen. In den Kreis seiner Betrachtungen zog er alles ein, was irgendwie mit dem Wirken des Magmas in und auf der Erdoberfläche im Zusammenhang steht. Sein Ziel war, die Mannigfaltigkeit der Erscheinungen aus dem Stoff und seinen Zustandsgrössen Druck und Temperatur abzuleiten. Der Vulkanismus ist also in seinem Sinne die Lehre von dem Empordringen und der Gestaltung des Magmas. Die Erörterung über die Magmazone führte zur Gesteinssystematik, zur Unterscheidung von drei Gesteinsreihen oder Sippen, der atlantischen, pazifischen und arktischen Sippe. Die letztere Sippe umfasst nach von WOLFF alle selbständigen basaltischen Magmen und ihre Spaltungsprodukte in den zirkumpolaren Gebieten.

Bevor von WOLFF dann an die Beschreibung der Methoden der speziellen Vulkankunde und der einzelnen Vulkangebiete heranging, widmete er sich zunächst einem ausserordentlich wichtigen petrographischen Problem, nämlich der Frage einer quantitativen Klassifikation der Eruptivgesteine. Erst mit der Klärung dieser Frage war es möglich, eine vergleichende Petrographie aller vulkanischen Gesteine zu betreiben. Das Ziel war, eine Klassifikation zu finden, die es gestattet, ein nach petrogenetischen Gesichtspunkten aufgebautes Einteilungsprinzip der Eruptivgesteine zu finden. Da die Gesteine heterogene Gemenge von Mineralien sind, stösst die Schaffung einer quantitativen Gesteinssystematik auf gewisse Schwierigkeiten. F. von WOLFF entschloss sich zu einer Systematik, die es gestattet, Magmen über weite Räume zu vergleichen. Da eine Darstellung in der Ebene anschaulicher ist, wählte er zur Charakterisierung der stofflichen Zusammensetzung der Gesteine ein gleichseitiges Dreieck mit den drei Veränderlichen L, M und Q. Diese drei Komponenten entsprechen den normativen hellen oder leukokraten Bestandteilen, den dunklen oder melanokraten Bestandteilen und der Kieselsäure. Der Vorteil dieser Darstellung der Gesteine als Dreistoffsystem liegt in der Möglichkeit, aus der Dreiecksprojektion Differentiations- und Assimilationsbahnen sowie Eruptionsfolgen abzulesen.

Nachdem im Jahre 1922 der Schlüssel für die Gesteinsberechnung gefunden war, ging F. von WOLFF daran, Hunderte von Gesteinsanalysen zu berechnen. Sie bildeten die Grundlage für den speziellen Teil seines Vulkanismus, der in den Jahren 1923, 1929 und 1931 erchien und heute eine einzigartige Übersicht über alle aussereuropäischen Vulkangebiete darstellt. Waren die vulkanologischen Arbeiten bis dahin im wesentlichen Beiträge zur Beschreibung und Systematik der Ergussgesteine, so beschäftigte sich von WOLFF im Anschluss daran mit der Erforschung der Ursachen des Vulkanismus und mit Fragen der Gebirgsbildung, mit Problemen, die ihn bis in die letzten Tage seines Lebens beschäftigten. Sein Verdienst ist es, von der anfänglich nur beschreibenden Vulkanologie zur exakten Vulkanologie überzuleiten, indem er aus dem Stoff und seinem Zustand, also den Temperatur-Druckbedingungen, die Mannigfaltigkeiten der vulkanischen Erscheinungen erklärte. Er fand im Jahre 1928 das Temperaturgesetz in der Erdkruste, schrieb 1931 über das Erdinnere, setzte sich 1938 mit den Zustandsgrössen, die den Santorinausbruch bestimmten, auseinander und beschäftigte sich 1940 mit dem Gesetz des Vulkanismus. In den Nachkriegsjahren vervollständigte er die Beschreibung aller Vulkangebiete der Erde durch eine Monographie über den Vulkanismus des Mittelmeerraumes und beschrieb den grossen Vesuvausbruch des Jahres 1906. Gerade am Beispiel der Mittelmeervulkane zeigte von **Wolff**, wie man unter Ausnutzung des vorhandenen Beobachtungs- und Tatsachenmaterials auch zu Schlüssen über bisher unbekannte Eigenschaften und Vorgänge kommen kann. So konnte er z.B. zahlenmässig die Länge der Vulkanschlote und die Lage der Ausbruchszentren für jeden Vulkan angeben. Darüber hinaus zeigte er die Zusammenhänge auf, die zwischen der Viskosität der vulkanischen Magmen und ihrer Zusammensetzung hinsichtlich der gasförmigen und festen Bestandteile sowie den äusseren Erscheinungsformen der Vulkane bestehen. Alle diese Berechnungen konnten aber auch in Einklang mit dem geologischen Erkenntnissen gebracht werden, und dies gilt insbesondere für die Frage nach der Ursache vulkanischer Ausbrüche.

Es war ganz natürlich, dass dem vulkanologischen Studium petrographische Arbeiten parallel liefen. Insbesondere standen im Brennpunkt seines Interesses die Fragen über die Petrogenese der Gesteine, über das Alter, über Intrusionsniveau und Intrusionstemperatur, sowie über die Zusammensetzung des Urmagmas und über das Granitproblem.

Die Krönung seiner petrographischen Erkenntnisse bildet seine « *Gesteinskunde* », die im vergangenen Jahr erschien. Mit diesem Werk, das das Ergebnis jahrelanger petrographischer Untersuchungen und Berechnungen darstellt, hat uns F. von **Wolff** ein Geschenk hinterlassen, das für Lernende und Lehrende eine ausgezeichnete genetische Systematik der Eruptivgesteine bildet. Mehrere Tausend Gesteinsanalysen wurden in L, M, und Q-Werten umgerechnet und in diesem Buch verarbeitet und zwar mit einer Übersichtlichkeit, wie sie bisher in keiner Gesteinskunde zu finden war. Durch eine straffe Systematik war es F. von WOLFF möglich, für die Tiefengesteine und für die Ergussgesteine je 4 Differentiationsreihen aufzustellen, die einen guten Überblick über die Gesamtheit aller Eruptivgesteine vermitteln.

Die wissenschaftliche Bedeutung von WOLFFS liegt zweifellos auf dem Gebiete der Vulkanologie und Petrographie. Es wäre jedoch falsch, wollte man behaupten, er hätte die anderen mineralogisch-petrographischen Arbeitsrichtungen vernachlässigt.

Vielmehr beschäftigte er sich auch mit rein kristallographischen oder mineralogischen Themen. So führte er kristallographische Untersuchungen an Ferrocyan-Thalliumkalium, an Cholesterin und am Hittdorfschen Phosphor durch, gab in den Jahren 1922-1924 kleine Lehrbücher über allgemeine und spezielle Mineralogie heraus und schrieb im Jahre 1928 eine Einführung in die Kristallstrukturlehre. Besondere Bedeutung erlangte sowohl für die Mineralogie als für die Petrographie die von F. von WOLFF eingeführte Methode der mechanischen Phasenanalyse im Jahre 1927. Es war seitdem möglich, die Mineralkomponenten eines Gesteines quantitativ zu trennen. Moderne Zentrifugen und neue Zentrifugengläser zur Durchführung quantitativer Mineral- und Gesteinstrennungen wurden entwickelt.

Die letzten Jahre wissenschaftlicher Forschertätigkeit standen im Zeichen der Schaffung einer allgemeinen Synthese alles dessen, was in jahrzehntelangem Bemühen an wissenschaftlichen Erkenntnissen und Ergebnissen errungen war. Bis zuletzt beschäftigte sich F. von WOLFF mit den Kräften und Reaktionen, die das Antlitz unserer Erde geprägt haben. Bis zuletzt arbeitete er in ungebrochener geistiger Frische und erfüllte die letzten Worte seiner Selbstbiographie, wo es heisst: *So lange meine Hand die Feder noch führen kann, gilt mir der Wahlspruch der Akademie « Nunquam Otiosus »*.

Noch auf seinem Krankenlager schrieb er die letzten Worte einer Monographie zum Problem der Gebirgsbildung, in der er die wichtigen Fragen der Gebirgsbildung, des Vulkanismus und Plutonismus, des Granitproblems und der Gebirgszyklen noch einmal zusammenfassend behandelt.

In einer weiteren grösseren Arbeit, die ebenfalls im Manuskript vorliegt, schrieb er über Vulkanausbrüche, Erdbeben und Gebirgsbildungen und gab darin einen Querschnitt über den gegenwärtigen Stand der Geologie, Mineralogie, Petrographie und Geophysik.

Das sind Arbeiten, die nur ein Wissenschaftler zu schreiben vermag, der sich in jahrzehntelangem Ringen ein umfassendes Bild von dem gegenwärtigen Stand der Naturwissenschaften zu machen in der Lage war. Ihm war es noch, wie nur wenigen vergönnt, Rückschau zu halten und sein Weltbild in zwei letzten Monographien der Nachwelt zu hinterlassen.

In diesen letzten Arbeiten kommt von Wolff zu folgenden Thesen:

1. Die Gebirgsbildung setzt den magmatischen Zyklus in Bewegung, sie ist die Ursache des Magmatismus.
2. Der Magmatismus schliesst den Vulkanismus und den Plutonismus in sich.
3. Granite und verwandte Tiefengesteine können nur auf zwei verschiedenen Wegen entstehen. Die einen Granite sind aus dem Schmelzfluss entstanden, Orthogranite, die anderen sind durch metasomatische Verdrängungen aus sedimentären Altbeständen entstanden, das sind die Paragranite, also metamorphe Gesteine.
4. Seit etwa 2 Milliarden Jahren besteht auf der Erde ein Gleichgewicht.
5. Das Gleichgewicht wird periodisch durch 5 Gebirgszyklen gestört. Geosynklinalzeiten sind Zeiten der Aufheizung. Orogenperioden sind Zeiten der Abkühlung.

So hat uns F. von Wolff eine Vielzahl wertvoller Werke und die Früchte seines wissenschaftlichen Lebens in einigen Arbeitshypothesen hinterlassen.

Auf der Höhe seines Schaffens wurde ihm in Anerkennung seiner Verdienste die Goethe-Medaille für Kunst und Wissenschaft verliehen.

In seinem Institut aber war er nicht nur Wissenschaftler und Forscher, sondern auch als Persönlichkeit und Mensch hochgeachtet. Wir werden sein Andenken stets in Ehren halten.

Dr. RUDOLF GAEDEKE

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THOMAS AUGUSTUS JAGGAR

THOMAS AUGUSTUS JAGGAR

(1871 - 1953 †)

Dr. T. A. JAGGAR, dean of American volcanologists, died in Honolulu on January 17, 1953, just one week before his 82nd birthday.

Thomas Augustus JAGGAR, Jr., was born in Philadelphia, Pennsylvania, on January 24, 1871. His father was a Bishop of the Protestant Episcopal Church. Young JAGGAR was educated in public and private schools in Philadelphia; Cincinnati, Ohio; and Montreux, Switzerland. In 1893, he graduated from Harvard University with the A. B. degree in geology. The next year he received his M. A. degree, also from Harvard. During the following two years he studied mineralogy under Prof. Paul GROTH at Munich and petrography under Prof. Harry ROSENBUSCH at Heidelberg. Returning to Harvard, he took his degree of Doctor of Philosophy under Prof. John E. WOLFF, in 1897, with a dual thesis dealing with the determination of hardness of minerals in microscopic section, and with the nature of clastic inclusions and their bearing on the origin of micropegmatite in diabase dikes in the Boston Area.

In 1895, JAGGAR was appointed Instructor in Geology at Harvard University, and in 1903 he was made Assistant Professor. During this interval he was also a member of the United States Geological Survey, working under S. F. EMMONS in the Black Hills region of South Dakota and adjacent parts of Wyoming, and under Arnold HAGUE in the Yellowstone region of Wyoming. The former work led to the publication, in 1901, of his first big-paper, an important study of the laccoliths of the Black Hills. A report on the petrography of the Absaroka Range in Wyoming was prepared for the Geological Survey's memoir on the geology of Yellowstone National Park, but like the rest of the first volume of that memoir, was never published. In 1900 and 1901 he worked with Charles PALACHE in the Bradshaw Mountains in Arizona. In 1906, JAGGAR was appointed Professor and Head of the Department of Geology in the Massachusetts Institute of Technology.

Dr. JAGGAR's approach to geology was a dynamic one. While he was still a student he became interested in the application of experimental methods to geologic processes. Results of his laboratory experiments on stream erosion and sedimentation were published in 1908. He was more interested, however, in applying the same sort of methods in the field, in an attempt to measure and analyze geologic processes actually in operation under natural conditions.

In 1902, Dr. JAGGAR visited the West Indies to study the eruptions of Mont Pelée on the island of Martinique, and La Soufrière Volcano on St. Vincent Island. He saw there dynamic geology in its most dynamic aspect, and the tragic results of great volcanic catastrophes. He was impressed with the need for careful scientific studies of volcanoes, and saw how such studies would fit in with his interest in experimental geology. It was then that he decided to undertake the field study of geophysics as his life work. It is interesting to note that the same catastrophe at St. Pierre was the factor that guided into volcanology the other of the two greatest American volcanologists of the early 20th Century, Frank Alvord PERRET.

In 1906, Prof. JAGGAR visited Italy, to study the eruption of Vesuvius. He found PERRET already there, working as a volunteer assistant to Prof. MATTEUCCI, then Director of the Vesuvius Observatory. In 1907, JAGGAR was the leader of the expedition sent by Massachusetts Institute of Technology to the Aleutian Islands. Many of the islands were visited, and geologic collections were made by JAGGAR and Prof. Arthur S. EAKLE, but the objects of JAGGAR's special studies were Makushin and Bogoslof Volcanoes. In 1909, Prof. JAGGAR and his colleague, Prof. R. A. DALY, visited the Hawaiian volcanoes, and JAGGAR went on to Japan to visit the laboratories and stations of the Imperial Earthquake Investigation Committee. At that time began his long friendship with Prof. F. OMORI, which ended only with OMORI's tragic death in 1923. In 1910, JAGGAR and Prof. Charles M. SPOFFORD, of Massachusetts Institute of Technology, visited Central America to study the results of the great Cartago earthquake and the volcanoes of Costa Rica. On their return trip to Boston, they stopped at Jamaica, to examine the work being done there in the enforcement of earthquake-proof construction following the disastrous earthquake of 1907.

Prof. JAGGAR became more and more impressed with the small amount of knowledge possessed by men of science regarding the earth processes that bring about great natural disasters, and with the small amount of effort being expended in the attempt to acquire that knowledge. There were, to be sure, a few places, such as the Vesuvius Observatory and the stations in Japan, where work along those lines was in progress. Most geologists, however, though interested in such things, had little knowledge of earthquakes or volcanoes. Geologic effort was going almost wholly into the investigation of the history of the earth. But the time had come, he felt, when studies must be directed toward the humanistic aspects of geology. Instruments applicable to the study of earth processes already existed, and others must be developed. A program must be launched having as its goals the prediction of volcanic eruptions and earthquakes, and the development of engineering and types of construction to help lessen the disastrous consequences of such cataclysms. He was convinced also that the method of studying volcanoes and earthquakes by means of brief expeditions to the affected areas was inadequate, and that permanent observatories were needed in volcanic and seismic lands to keep constant record of all volcanic and seismic activity.

In July 1909 the Massachusetts Institute of Techonology received from the trustees of the Estate of Edward and Caroline WHITNEY of Boston, a bequest of $ 25,000 to be used for research and teaching in geophysics, with a view to the protection of human life and property. JAGGAR was, of course, enthusiastic. He and DALY had already examined the Hawaiian volcanoes, with a view to a possible future station there, and it was decided that Kilauea would be the best place for the new station. In this way did JAGGAR enter upon his true life's work — the establishment and operation of the Hawaiian Volcano Observatory.

Part of the WHITNEY fund was soon used for the construction, under the supervision of Drs. A. L. DAY and E. S. SHEP-

HERD of the Geophysical Laboratory of the Carnegie Institution of Washington, of resistance thermometers for the measurement of the temperature of molten lava in the Kilauea lava lake. A cableway was designed and built, for spanning Halemaumau Crater, in order to lower the thermometers into the lake. Dr. SHEPHERD's services were obtained for the summer of 1911, to make the temperature measurements. It was not possible, however, for JAGGAR or any of the other professors at M.I.T. to go to Hawaii at that time. Therefore arrangements were made with the Volcanic Research Society of Springfield, Massachusetts, for Frank A. PERRET to accompany Dr. SHEPHERD to Hawaii. They reached Kilauea on July 2, 1911, built an observation station on the rim of Halemaumau Crater, and after much difficulty succeeded in obtaining a measurement of the temperature of the lava (1000° C. about a meter below the surface of the lake). After the completion of the temperature measurements SHEPHERD returned to Washington, but PERRET remained at Kilauea until November 1911, and initiated the systematic observations and reports on activity that still continue. Prof. JAGGAR finally succeeded in getting leave of absence from M. I. T. in December 1911, and reached Kilauea on January 17, 1912. On March 6 he was recalled to Boston, but on June 13 he was back again accompanied by Dr. H. O. WOOD, who became the first seismologist of the Hawaiian Volcano Observatory.

From that time on the Hawaiian Volcano Observatory was the focal point of Dr. JAGGAR's interest. Things were not easy. The income from the WHITNEY fund, $ 3,500 a year, was not sufficient for the operation of the Volcano Observatory, and it expired altogether at the end of five years. An additional $ 5,000 a year was subscribed by the Hawaiian Volcano Research Association, and money for the construction of the Observatory building was subscribed by the people of Hilo. Often there was not enough money to pay for the work and instruments that were needed for the proper prosecution of the program. It is a fine tribute to JAGGAR's determination and singleness of purpose that even in the hardest and most discouraging of times he did not falter, but somehow kept the volcano investigation program going.

In 1919, the Hawaiian Volcano Observatory was taken over by the United States Weather Bureau, which at that time was charged with the investigation of earthquakes in the United States, and Dr. JAGGAR became an employee of the United States Government. In 1924 the operation of the Volcano Observatory passed from the Weather Bureau to the United States Geological Survey, and in 1926 the Geological Survey established a Section of Volcanology, with JAGGAR as its Chief. There followed the establishment of the Lassen Volcano Observatory in California, and a station at Dutch Harbor, Alaska, under JAGGAR's general supervision. Investigations of the Aleutian volcanoes were begun by JAGGAR in 1927, and continued by R. H. FINCH, volcanologist in charge of the Lassen Observatory, in 1931 and 1932. The Survey's Section of Volcanology was disbanded in 1935, and both the Hawaiian and the Lassen Volcano Observatories were taken over by the National Park Service. Dr. JAGGAR became an official of the Park Service, and remained one until his retirement in 1940.

Work at Kilauea was diversified. Most of the early work was related in one way or another to the Kilauea lava lake. To routine seismology and continuous recording of the activity of Kilauea and Mauna Loa were added: observations on the rise and fall of the level of molten lava in Halemaumau; measurements of the temperature of the lava at various depths in the lake; sounding of the depth of the lake; experiments on the viscosity of the lava; collection of volcanic gases for chemical analysis; measurements of the tilting and lateral shifting of the ground surface; borings to ascertain the nature of the lavas beneath the crater floor and the distribution of temperature in them; attempts to discern tides in the lava lake, and to correlate volcanic changes with astronomical forces or to identify other long-term cyclical behaviour; study of the different types of lavas and how they form; petrographic study of the rocks. No phase or feature of the volcanoes remained uninvestigated if JAGGAR or his associates could find means to attack it. In the field of seismology, experiments were made with improved methods of recording distant, as well as local, earthquakes; and a special study was made of tsunamis, and possible means of predicting them.

Occasional expeditions were made to other volcanic and seismic areas. In 1914 JAGGAR visited Japan, to study the eruption of Sakurajima Volcano. In 1923 he was again in Japan, to study the results of the great Yokohama-Tokyo earthquake. In 1920 he visited New Zealand, to advocate the establishment of a volcano observatory there. In 1924 he visited Baker and Howland Islands, as a member of the Whippoorwill Expedition, jointly sponsored by the B. P. Bishop Museum and the United States Navy. In 1927 he initiated the Geological Survey's volcano investigations in the Aleutian Islands, and in 1928 he was the leader of the National Geographic Society's Pavlof Expedition to the Alaskan Peninsula. In 1930 he was geologist for the U. S. Naval Observatory's Eclipse Expedition to Niuafo'ou Island. Transportation difficulties in the Aleutian Islands led to his design and construction of an amphibian boat, used successfully during the Pavlov Expedition in 1928. This amphibian was the fore-runner of military amphibian vehicles used by American forces during the Second World war, and its invention won him, in 1945, the Franklin Burr Prize of the National Geographic Society.

After his retirement from Government service, in 1940, Dr. JAGGAR became research associate in geophysics at the University of Hawaii. He still retained that position at the time of his death. Much of his time at the University was spent on compilation of the results of his volcano studies at Kilauea, but he also devoted thought and study to the cause of such eruptions as that of Mont Pelée in 1902, and returned to one of his earliest interests — that of the precise measurement of hardness of minerals and other substances.

For many years JAGGAR was intensely interested in the sea bottom. The 72-per cent of the earth's surface concealed by deep ocean water was a challenge to his imagination and curiosity. He sought for ways to explore it, and advocated drilling into it from great floating seadromes, using deep-well oilfield equipment or some suitable modification of it. He was a good mechanic, and thoroughly recognized the mechanical difficulties of such drilling, but he was confident that the difficulties could be overcome.

JAGGAR was much interested in astronomy, and spent evenings at his telescope observing the face of the moon, and other heavenly bodies. He was especially interested in the moon, in whose craters he saw an analogy to the great volcanic depressions of the earth. Interest in astronomy and in boats and navigation combined in his development of instruments and methods for locating the geographical position of a ship or airplane by observation of the stars in the region of the zenith.

Not even all of these interests and activity could fully occupy him. He entered the fields of philosophy and religion, with essays on Jesus; the origin of the earth, life, and man; evolution; and the trends of science. While he was still in Massachusetts he became interested in the problems and methods of education. In his later life his interest in education continued to be expressed through his service on the governing board of the Iolani School in Honolulu.

It is hardly necessary, in this journal, to point out the importance of JAGGAR's contribution to the science of volcanology. Volcanologists and geologists interested in volcanoes are too well acquainted with it for further comment to be necessary. It is interesting, however, to note the general change that has taken place in the science during the preciselv 41 years between JAGGAR's arrival at Kilauea to establish the Volcano Observatory and his death. In 1912 volcanology as a true science was just emerging from a largely descriptive phase into one of controlled interpretation and experimentation. The companion science of geophysics was very new. Today we have advanced to a stage where we are beginning to realize the fruits of the labors of our predecessors, where our knowledge is sufficiently complete and accurate to make some prediction possible. A great deal remains to be learned, indeed much more than we have learned thus far! Nevertheless the advancement has been appreciable, and to this advancement JAGGAR was one of the principal contributors, through his own work, and through his direction of the work of his associates.

Dr. JAGGAR's belief in the supreme importance of the humanistic aspect of volcanology, indeed in the humanistic aspect of all science, would lead him to consider his greatest contribution to be the development of methods to protect important populated areas from destruction by lava flows. **Jaggar** and his associates in Hawaii have demonstrated the practicability, when conditions are favorable, of retarding the advance of a flow front or completely diverting the flow to a new channel, by means of aerial bombing. He also proposed a method for deflecting flows from cities or harbors by the construction of long barriers. Always standing as the ultimate goal of **Jaggar**'s endeavours was the motto of the Hawaiian Volcano Research Association: « *Ne plus haustae aut obrutae urbes* » — « *No more shall the cities be destroyed* ».

Gordon A. Macdonald
Director, Hawaiian Volcano Observatory
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Dixième Assemblée Générale de l'Union Géodésique et Géophysique Internationale

Rome, 14 - 29 septembre 1954

BUREAU CENTRAL INTERNATIONAL DE VOLCANOLOGIE

Pour la correspondance :
Prof. FRANCESCO SIGNORE
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Naples, avril 1953

Mon cher Collègue,

J'ai l'honneur de vous faire savoir que la Dixième Assemblée générale de l'Union géodésique et géophysique internationale aura lieu à Rome du 14 au 29 septembre 1954.

Je vous prie de vouloir bien m'envoyer *au plus tôt possible* vos propositions personelles (ou celles du Comité national de Volcanologie par vous éventuellement présidé) pour rédiger l'*Ordre du jour* des séances..

Chaque thème ou proposition doit être suivi par un abregé ou dilucidation de l'argument qu'on entende traiter.

Dans l'espoir que vous serez présent è cette session, je vous prie d'agréer l'assurance de ma parfaite considération.

Le Secrétaire général
F. SIGNORE

Aux Présidents et Secrétaires
des Comités nationaux de Géodésie
et Géophysique

Aux Membres des Sub-comités
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